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Geographical distributions of dog attacks on koalas and their local's awareness: a case study in Lemon Tree Passage, New South Wales, Australia

（コアラへのドッグアタックの地理的分布とそれに対する地元民の意識 -オーストラリアのニューサウスウェールズ州の Lemon Tree Passage を事例として-）

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Master thesis

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- オーストラリアのニューサウスウェールズ州の **Lemon Tree Passage** を事例として - **(英文)**

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新井　風音

要旨

この何年かの間、人間は経済的発展を目的として、例えば農地や住居などによって広大な土地を開発してきた。その結果、世界中の多くの種がすでに姿を消し、現在も、数多くの種が絶滅の危機にさらされている。

オーストラリアの在来種であるコアラも、その危機にさらされている種の１つである。彼らの生存は、主に生息地の減少により脅かされている。さらに、オーストラリアにおける急激な都市化により、生息地の減少だけでなく、ロードキル（車などに轢かれること）や病気やドッグアタック（犬に襲われること）といったそのほかの人為的な問題も、彼らの生息数を劇的に減少させている。これらの人為的な要因の中で、ドッグアタックは、コアラにとって、生息地の減少とロードキルに次ぐ３番目に最も大きな脅威である。また、コアラへのドッグアタックのほとんどが犬の飼い主の家の庭で起こっていることから、その防止は、多いに飼い主に依存すると考えられる。

したがって、この研究ではドッグアタックに焦点を当てることとし、コアラへのドッグアタックの地理的分布傾向、地元民の意識、地元の政策の効果とその課題を明らかにする。具体的には、住宅地のどこでドッグアタックが起こっているのか、どれくらいの飼い主がそのドッグアタックを防ぐための措置策をとっているのか、どれくらいの地元民がドッグアタックの脅威を認識しているのか、コアラに関する標識は適当な場

所・内容であるか、市における犬の管理に関する政策がどのように実施されているかとその課題について調査した。

調査地としては、ドッグアタックの発生密度と発生件数がともに最も大きかったLemon Tree Passageを選んだ。Lemon Tree Passageは、ニューサウスウェールズ州にあり、ニューカッスルの近くに位置する。さらに、Lemon Tree Passageが属するPort Stephens市に対して、犬の管理に関しての政策についてメールでの問い合わせを行った。

結果は、サウスオーストラリア州（SA）とクイーンズランド州（QLD）のそれぞれで、ドッグアタックの密度が高い場所が見つかった。また、その分布は、土地利用の観点から見て、どちらの州でも主要都市の周辺の居住地域に集中していた。一方で、田舎と都会を区別する区画の地図上では、異なる分布傾向を示した。具体的には、SAは都会発生型と考えられ、ドッグアタックは主要都市の近い都会地域で主に起こっている。それとは対照的に、QLDは田舎発生型と考えられ、ドッグアタックは大都市から離れた内陸の田舎地域で多く発生している。しかし、ドッグアタックは、その地域での中心地として機能しているであろう郊外や田舎地域でも発生するという点では、SAとQLDには共通点も見られた。よって、コアラへのドッグアタックは、州全体ではなく、小さな地域単位での人口規模と都市機能が関連しているようであることがわかった。

Lemon Tree Passageでどれくらいの飼い主がコアラへのドッグアタックを阻止するための対策をとっているかについては、観測された犬のうち、約30%が夜間も外にいる状態だった。夜間はほとんどのコアラへのドッグアタックが起こる時間帯である。これは、犬を夜間は室内に入れることについて、市から何の教育もなされていないためだと考えられる。例えば、観測された8個のドッグアタックに関する標識のうち、1

つのみが犬を夜間はフェンスに入れることというメッセージを発していたが、それも犬を夜間に室内に入れることよりも効果は薄いと考えられる。なぜなら、コアラが通り過ぎるかもしれない「屋外」に犬がいることには変わりないからである。また、Lemon Tree Passage の場合、たとえ犬がフェンスの中にいたとしても、犬は自由にそのフェンスの中を動き回れる状態だったので、コアラを襲う可能性は十分にある。よって、犬をフェンスの中に入れるという行動はドッグアタックを防ぐのにはほとんど効果がないと考えられる。

続いて、地元民へのアンケート調査によって、彼らがコアラにとっての犬の脅威を認識していないことが明らかになった。これは、飼い主へ教育がなされていないことに起因すると考えられ、実際に 60%の回答者が、市によるコアラへのドッグアタックについての教育は不十分だと答えている。さらに、市役所へのメールでの問い合わせの結果、コアラへのドックアタックが主に発生する夜間に、日常的に犬をパトロールすることの困難が明らかになった。なぜなら、パトロール業務を行う職員は日中に働いており、その他の仕事も多く抱えているからである。
従って、行政の限られた運営体制と犬を持つ飼い主の責任の双方の観点から、飼い主に対する教育の重要性が明らかになった。そして、彼らが自分たちでコアラへのドッグアタックを防げるようになることが求められる。

結論として、コアラへのドッグアタックは、都市と農村で違いが見られた。そして、Lemon Tree Passage では、標識の位置・場所・数、地元民の意識、行政の政策において、ドッグアタックへの対処が不十分であることがわかった。今後の課題としては、教育を強化し、犬の飼い主自身が責任を持ってドッグアタックを防ぐ体制作りをすることであろう。

Summary

Over the years, human have been developing wilder range of lands for e purposes such as agriculture or housings. As a result, many species in the world have already disappeared and still countless number of species is under the course of extinction.

Koalas, Australia's native species, are also one of them and their survival has been threatened mainly because of habitat loss. What is more, in the rapid urbanization in Australia, not only habitat loss but also other human-induced problems such as road kills, disease, and dog attacks have been dramatically reducing the koala population. Among those anthropogenic causes of decline in koala population, dog attacks are the third largest threats to koalas after habitat loss and road kills. Furthermore, most dog attacks on koalas take place in dog owners' own yard, suggesting that its prevention is largely dependent on dog owners.

Therefore, this research focuses on dog attacks on koalas and reveals their geographical distribution patters, awareness of local people, and effectiveness and challenge of the local policies on them. In detail, where in residential areas dog attacks on koalas happen, how many dog owners take actions for preventing them, how many the

locals recognize their threads, whether signs on koalas locate proper places and have appropriate messages, and how each policy on dog management is implemented at the council as well as their challenges were investigated.

Lemon Tree Passage in New South Wales, located close to Newcastle, was selected as study area because the highest density and number of dog attacks occurred in the area. Furthermore, an email inquiry as to dog management policy in the Port Stephens Council where Lemon Tree Passage belongs to was undertaken to see how each policy is implemented and its effect.

The results showed two clusters of high dog attack density areas in South Australia (SA) and Queensland (QLD) each and both of their distributions were mostly centered at residential areas around a major city at each state in terms of land use. On the other hand, when it comes to urban and rural classifications, their distributions illustrated different patterns. In detail, dog attacks distributions of SA are regarded as urban type where their distributions primary occurs at urban areas close to the major city. In contrast, distributions pattern in QLD is considered as rural type where dog attacks take place at rural areas of inlands, which are far away from the large city. However,

similarity in SA and QLD is also found in that dog attacks on koalas also happen at sub-urban areas or even in rural areas that would serve as rural city in the region. Thus, dog attacks on koalas appear to have some relations to population size and city function in each small area rather than in the state overall.

As for how many dog owners take preventive actions against dog attacks on koalas in Lemon Tree Passage, approximately 30% of dog observed were outside at night when most dog attacks on koalas take place. This is considered to be because no educations on the need of keeping dog inside at night were provided by the Port Stephens Council. For example, out of eight signs on dog attacks, only one said keeping dog fenced in at night, which will not be as effective as keeping dog inside considering dogs are still outside where koala may walk across. Furthermore, in the case in Lemon Tree Passage, even if dogs are kept inside fences, dogs could freely move inside and could attack koalas, meaning keeping dog fenced in has little effect on preventing dog attacks on koalas.

Additionally, a questionnaire to local people presented unrecognition of dogs as threats to koalas. This is considered to result from the absence of education to dog attacks on koalas because 60% of

respondents said the council's education on dog attacks on koalas is insufficient. What is more, an email inquiry to the council shows the difficulty of patrolling dogs at night, when dog attacks on koalas mostly happen, on a daily basis because the staff who are in charge of patrolling have day shift and also have plenty of other task. Thus, both in terms of limited administrations in government and dog owners' responsibilities, the need of educations to dog owners so that they can prevent dog attacks on koalas by themselves was revealed.

In conclusion, distribution patterns of dog attacks on koalas were different in urban and rural areas. Furthermore, in Lemon Tree Passage, preventions to the attacks were insufficient in terms of places, contents, and number of signs related to dog attacks, local's awareness, and local policies. Thus, it is important to enhance education to dog owners so that they themselves can take preventive measures against dog attacks on koalas, effectively addressing them.

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1. Introduction

1.1 The impact of dog attacks on koalas

Over the last 50 years, humans have been rapidly developed wider range of landscapes for economic and social purposes such as agriculture, housing or roads, resulting in extensive loss of species (Mace& Baillie, 2005) and their elevated extinction rate (Campagna et al, 2011). Even now, countless number of species is under threats (Cardinale et al, 2012) and koala is one of them.

In Australia, koalas have been the icon of the nation (Stratford et al, 2000) and its contribution to tourism, cultural identity (Hamilton, 1997) and education on wildlife conservation (Simberloff, 1998; Maan et al, 2011) are significant. For example, koalas are estimated to create $1.1 billion per year, which makes up 10% of the national tourism revenue in Australia, along with 9000 jobs. They are by far the most popular native animals with overseas tourists, with 72 % of them wanting to see koalas in Australia (Hamilton, 1997). Thus, koala conservation is important in Australian social, economic, and cultural contexts.

However, dogs, especially domestic dogs threaten the survival of koalas (Lee & Martin, 1998; Queensland Environmental Protection Agency (QLD EPA), 2006a; McAlpine et al, 2007). Dog attacks on koalas are the

third biggest cause of koala decline after habitat loss (Australian and New Zealand Environment Conservation Council (ANZECC), 1998) and road kills (Melzer et al, 2000; McAlpine et a,l 2006; Dique et al, 2004). For example, an average of 300 koalas die each year due to dog attacks in south-east Queensland, based on records from 1997 and 2011 (QLD EPA, 2006a; Queensland Department of Environment and Resource Management(QLD DERM), 2011c). This annual mortality equates to a 2% reduction in total koala population in 2010 in south-east Queensland, given that its population is 15000 in that year (Threatened Species Scientific Committee (TSSC), 2012p). This mortality rate by dog attacks is relatively high when viewed with respect to the mortality rate by road kills, the second largest cause for decreasing koala number, which is 5% on the Koala Coast (Dique et al, 2003). Furthermore, in areas with relatively high human population in Queensland (QLD) and New South Wales (NSW), studies show that dog attacks account for between 5% and 40% of total recorded mortalities (Schlagloth et al, 2006; McAlpine et al, 2007). What is more, more than 80 % of koalas die once they are attacked by dogs (QLD EPA, 2006a), and even if koalas survive after attacked, stress and injury from the attack often weaken koalas and cause diseases and infertility (Martin & Handasyde, 1990). In addition, the unhealthy status of koalas result in low

population growth (Gordon et al, 1990), and they become more vulnerable to dog attacks when weakened by health problems (Wilkes& Snowden 1998), creating a positive feedback loop that exacerbates the problem.

However, the frequency of koala death by dog attacks is uneven by places from where one koala dies every week in Redland shire (Queensland Department of Environment and Heritage Protection (QLD DEHP), 2011c), to where only three koala deaths are reported over two decades from 1991 to 2011 in Tweed Coast(Phillips et al, 2011). Although koala population in Redland is much higher than in Tweed Coast, with 1500(QLD DERM, 2008) and 144(Phillips at el, 2011) respectively, Phillips et al (2011) also attributes the small number of koala death by dogs in the Tweed Coast to lack of reporting. This is because most of dog attacks occur at night, when koalas are the most mobile (McAlpine et al, 2006) and are most likely to be on the ground (P.Smith &J. Smith, 1990) (Another cause of lack of reporting will be discussed later in 1.4). Attacks also often happen in bushland, especially in rural areas (Phillips et al, 2011), which are not frequently observed. Other research also shows that dog attacks are responsible for 24% to 40% of koala deaths on the Peninsula and 43% in Port Stephens (Lunney et al, 2004), in contrast to only for 6 % in Phillip Island, Victoria (Lee & Martin 1988) and 7% in Port Macquarie (Canfield,

1987). Although mortality rate by dogs is low in some areas, dog-induced mortality can have significant impact on both koala survival rate and their population numbers based on population viability analysis (Lunney et al, 2007).

On top of that, in contrast to habitat loss and road kills which extend to broader issues such as city planning, population growth, or even our lifestyles, prevention of dog attacks are thought to have higher feasibility. This is because dog attacks largely depend on how dog owners manage their dogs responsibly so that they do not attack koalas (QLD EPA, 2006b; QLD DERM, 2008). Thus, dog attacks on koalas need to be addressed considering their severe impact on koala populations and mitigation feasibility.

1.2 Where, when and how dog attacks on koalas take place?

Dog attacks on koalas mainly occur in urban areas such as small rural holdings close to urban centers, in semi-urban or rapidly urbanizing areas (Natural Resource Management Ministerial Council (NRMMC), 2009). For example, dog attack mortality becomes higher as dog densities increase(McAlpine et al, 2007) and dog densities is higher in populated urban areas than in rural areas(Acosta-Jamett et al, 2010). Thus, dog attacks on koalas seem to be more frequent in urban areas than in rural

areas. Moreover, the frequency of dog attacks in a suburb reveals a strong correlation with dog density in the suburb (QLD EPA, 2006b; de Villiers et al, in press), suggesting that dog attacks is closely associated with urbanization. However, they also occur in non-urban landscapes such as national parks, reserves and a range of rural residential areas (NRMMC, 2009; NSW National Parks and Wildlife Service (NPWS), 2003).

With regards to when dog attacks on koala take place, it is slightly different by states. More dog attacks occur between July and September, peaking in September in QLD (Nattrass & Fiedler 1996; QLD DEHP 2008) and between August to February in north coast of NSW (Leathley et al. 2001a) with a peak from September to October (NSW Department of Environment and Conservation (NSW DEC), 2003). This is because these periods are breeding seasons when koalas, particularly young males, move around the most (Nattrass & Fiedler 1996) to look for mates (QLD DEHP, 2008; Leathley et al, 2001a).

Concerning how dogs attack on koalas, when koalas enter into yards of households to search for food trees and look for mates in breeding season(QLD DEHP, 2008; Leathley et al, 2001a), dogs often end up biting koalas to protect their territory(QLD EPA, 2006b; QLD DEHP, 2008), leading the koalas to die.

1.3 Factors that have relation to dog attacks and propriety areas

Some factors coming from residence features, dogs and dog owners heighten the severity of dog attacks on koalas. In terms of residential characteristics, fenced yards are often associated with dog attacks both in urban and rural residential areas (NSW DEC, 2003). This results pause a questions on the effect of fences at yards against dog attacks because researchers, governments, other organizations recommend dog owners implement fences to exclude koalas from their yards(McAlpine et al, 2007; QLD EPA, 2006b; QLD DEHP, 2008). With regards to dogs, multiple dogs, large dogs, aggressive breed dogs, free roaming dogs outside their yards increase the likelihood of dog attacks (P. Smith &J. Smith, 1989, McAlpine et al, 2006; QLD DEHP 2008; NRMMC 2009). For instance, according to QLD DEHP (2008), dogs over 10kg account for 96% of attacks on koalas and the likelihood of fatal attack become higher as dogs are larger. However, a research suggests that even small dogs can inflict serious or fatal injuries to koalas (McAlpine et al, 2006). Those results indicate the need of targeting dog owners whose dogs are large in dog management as well as being careful on small dogs' owners to some extent. Concerning dog owners, irresponsible dog owners who, for example, let their dogs roam outside their yards or who do not train their dogs properly and therefore

make the dogs aggressive are also contribute to attacks on koalas (NRMMC 2009). Moreover, dog attack mortality is particularly problematic where high densities of dog ownership correspond to koala habitats and highly koala populated areas (McAlpine et al, 2006). Additionally, fragmented landscape in developed areas also increase occurrences of dog attacks on koalas (Laurance & Cochrance, 2001).

1.4 Preventive measures against dog attacks and their challenges

Research suggests preventions against dog attacks on koalas to dog owners both in the context of koala conservation and responsible dog ownerships. This is because those preventions are not specific only to koalas but are beneficial to wildlife in general (FitzGibbon & Jones, 2006). In detail, preventions are classified into three groups based on targets ranging from to dog owners, governments, and developers (Table 1). As for the actions for dog owners, keeping their dog inside at night or its alternatives (QLD EPA, 2006b; QLD DEHP, 2008; P. Smith & J. Smith, 1989; McAlpine, et al, 2007) is the most common. This action is also considered to significantly reduce the likelihood of attacks because most of attacks occur at night at yards (QLD EPA, 2006b; QLD DEHP, 2008). Koala friendly development such as dog free or small-dog estates (P. Smith&

J.Smith, 1989; QLD ELA, 2006a; McAlpine et al, 2007; QLD EPA, 2008) is another perspective. In fact, a koala friendly development has been established with the collaboration of the Australian Koala Foundation, a non-profit organization, a developer, and local movement on the northern New South Wales coast where no dogs are allowed (Australian Koala Foundation 2004b). Although controlling domestic dogs at private areas by governments is difficult because it is related to private property (Predavec, 2008), in some cases, governments can take away private dogs in the name of protecting koalas as is the case under Pine Rivers – Local Law 42 – Animal Control, Clause 26(2).

A feature in preventive measures on dog attacks on koalas is that little policy promotes use of signs for them, even if they have found to be effective for prevention of road kills on koalas by reducing speed limit though them (Smith, 1990; Prevett et al, 1992; Lunney et al, 1996; Martin & Handasyde, 1999; Melzer et al, 2000; QLD EPA, 2006b; Phillips et al, 2011; David et al, 2003; Glista et al, 2009; Laurance et al, 2009). However, the effectiveness of signs is limited unless other mitigation measures are implemented together (David et al, 2003; NSW DECC, 2008).

Table 1. Suggested preventions on dog attacks on koalas

Targets	Preventive actions
Dog owners	<How to keep dogs> Keeping dog inside, on lead, or enclosed at night <Yard designs> Koala excluding fences Ropes in swimming pools <Others> Training dogs not to chase koalas Choose small dogs Daily cautions
Government	-Increased regulation on dog control and dog registration -Education to dog owners -Impounding of roaming dogs -More off-leash dog exercise areas -Frequent patrolling -Monitoring of dog attacks -Delivery of wildlife friendly dog training workshops -Seek supports from dog related organizations such as vets, dog clubs or pet shops for better dog management initiatives -Restraining or confining the dog -Signs promoting awareness
Developers	Prohibiting or restricting dog ownership in new residential areas

Source: P. Smith & J. Smith, 1989; Ashworth、 1998; Port Stephens Counci、l 2002; McAlpine et al, 2007; QLD EPA, 2008; Redland Shire Council, 2012; QLD DEHP,2012; Logan City Council, 2014

Despite all the suggested preventions on dog attacks on koalas, no research shows effect of those preventions. Thus, assessment on which actions take effect or not in what kind of situation is unclear and it will make prevention of dog attacks on koalas difficult. For example, growing awareness to dog attacks on koalas, and attempt to address them among government, NGOs, and communities have yet to be proven to be effective for their solutions (TSSC, 1999, 13p). Moreover, Redland City in Queensland, which is home to the largest koala population in Australia, aimed reduced dog attacks on koalas through effective use of local laws and education programs by 2003 (Redland Shire Council, 2002). However, whether it was achieved or not is not available. Similarly, most of actions against dog attacks on koalas such as enforcement of new local law in QLD, website information and brochures in SA are still under way or planned (NRMMC 2010). Thus, evaluation of each action is yet to be researched. Therefore, assessment of each action and their continued monitoring are required for better preventions.

Apart from (1) the lack of evaluation of existing policies on dog attacks on koalas, other three problems are found; those include (2) unreported dog attacks derived from both difficulty to notice the attacks and people's reluctance, (3) uncertainty of cause of koala death, (4) tendency of some

dog owners' to release their dogs at night and unwillingness to enclose their dogs at night. As for the lack of reporting, the first reason is that most of dog attacks on koalas occur at night (EPA 2006) and in bush areas where people do not regularly notice(Phillips et al, 2011) as discussed before. The second reason is that dog owners are reluctant to say that their dogs attack koalas from the sense of guilty (Lunny et al, 1999). What is more, Lunny et all(1999) also mentioned whether the koalas is attacked by dogs often cannot be confirmed as they are found as dead, injured or the dead body is already old. Furthermore, some dog owners prefer to let their dog off-leashed at night, which is hard to control (Schlagloth et al, 2006). Likewise, some like to keep their dog outside even at night rather than restricting their dogs in closed areas (Ng et al, 2014). For example, Clark (2006) shows that dog owners who usually keep their dog at night are strongly against setting enclosures to their dogs at any stations. In summary, human social impediments as well as challenges inherent to dog attacks itself pose difficulty in manage dog attacks on koalas.

1.5 Research objective

Dogs are key threats to koala populations and they significantly contribute to koala mortality caused by anthropogenic factors (OLD EPA,

2006; New South Wales Department of Environment and Climate Change (NSW DECC), 2008). Therefore, many researches have explored dog attacks on koalas. However, two questions have yet to be answered.

Firstly, where in residential and rural areas dog attacks on koalas happen? Although most dog attacks on koalas take place in residential areas (OLD EPA, 2006; NSW DECC, 2008), their detailed distributions, for instance, those surrounded by agricultural areas, are not revealed. Moreover, despite the attacks number in rural areas are fewer than in residential areas (Phillips et al, 2011), where they occur also should be investigated. This is because low frequency of dog attacks implies high chance of completely eliminating them if addressed properly. 0% of dog attacks in rural area may have stronger positive impact on koala populations than halving high rate of dog attacks in urban areas. For example, Rhodes et al (2005) reveals that even 50% reduction of dog attacks mortality on koala shows significantly higher risk of decline in koala population than when the mortality is reduced by 100%.

Secondly, how many dog owners take actions against dog attacks on koalas and how they are distributed? In order to implement effective measures depending on how many dog owners take how much of actions, their distributions is needed. For example, government can particularly

patrol an area with low action rate for preventing dog attacks on koalas before dog attacks occur if their action rate and distributions are understood. However, little research deals with dog owners' actions and awareness. As one of a few researches, Logan City Council shows that 76% of dog owners surveyed always take actions to make their dog or yard koala friendly and that 40% of all respondents including non-dog owners always consider koalas in their back yard design (Logan City Council, 2012). However, where such households located remain unsolved.

Additionally, as local governments such as Redland City or Logan City provide dog owners with what they can do to prevent dog attacks on koalas, government policy is considered to have relation to their actions and awareness.

Therefore, the purpose of this research is to investigate (1) where in residential and rural areas dog attacks on koalas take place in Australia and (2) how much awareness do local people have in terms of dog owners actions against dog attacks on koalas along with their distributions and their consciousness, and (3)effectiveness of government policy and its challenge. Detailed questions to be explored in this research are shown in the Table 2 below. Finally, suggestions for what should be done to prevent dog attacks on koalas were made.

This study will contribute to the prevention of dog attacks and therefore the conservation of koalas in itself.

Table 2 Questions to be investigated in this research

Primary question	Detailed questions
(1)Where in residential and rural area dog attacks on koalas take place?	▪Where they are concentrated and why? ▪Do they occur in inlands or coast? ▪How their distributions change by year if it is distinctive?
(2)Awareness of local people	<Actions> ■How many dog owners keep their dog inside at night? ■Are their dogs small, medium, or large? ■How many dogs they have? <Consciousness> -About koalas in general ■How they are concerned on koalas? ■How often do they see koalas? -About their actions ■How many people take actions for preventing dog attacks on koalas? ■What actions they take? -About dog attacks on koalas ■Do they recognize that dog attacks to be the third biggest cause of declining number of koalas? ■What other causes do they thinks are threatening koalas? ■What measures would be effective to prevent dog attacks on koalas? ■Do they know threat of dogs for koalas? -About educations ■Are education on dog attacks on koalas enough? ■Do they think council take appropriate measures? ■Have they seen information on dog attacks on koalas and where?
(3) Effectiveness of government policy and its challenge	■Are signs located at where dog attacks on koalas are likely to take place? ■Are message of signs encourage appropriate actions? ■Are free-roaming dogs well controlled? ■How each policy on dog attacks on koalas is implemented and how effective they are? ■What are challenges in the policies?

2. Methods

Framework

This research contains two different scales from macro to micro scales (Figurer 1).

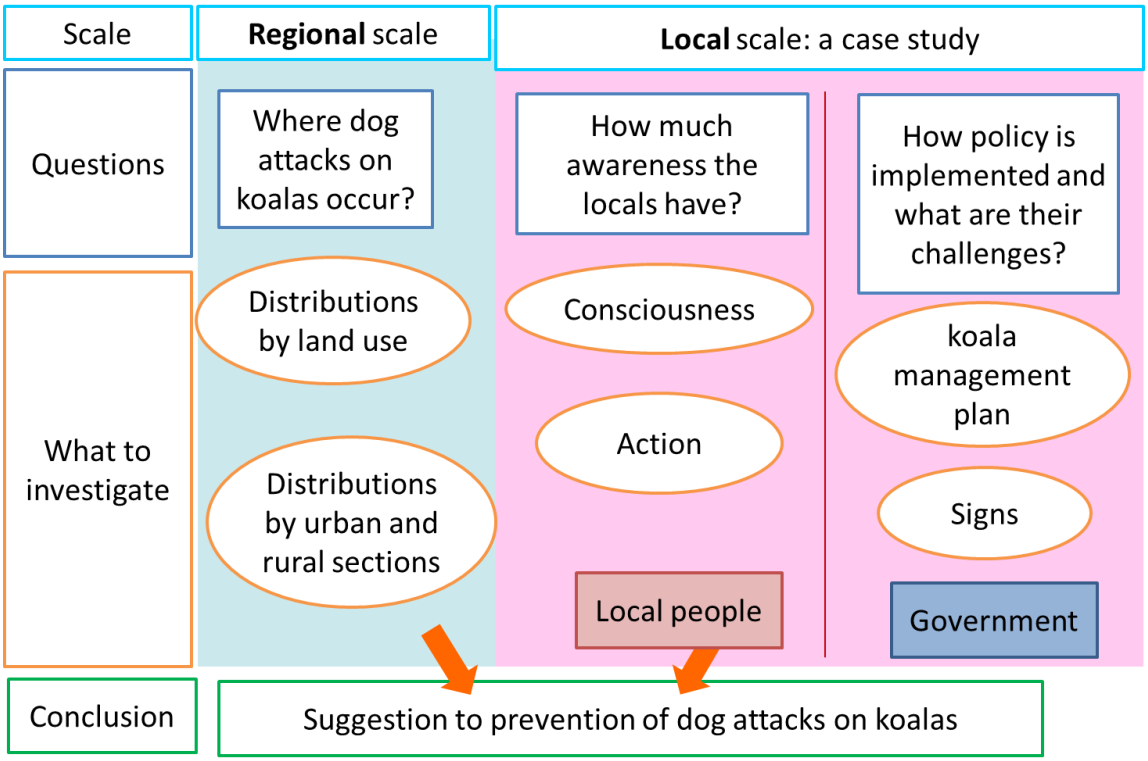

Figure 1 Framework of this research

Concerning distribution of dog attacks on koalas in Australia, their overall pattern was detected and explained at a regional scale. As to awareness to dog attacks on koalas, it has two types of indicators with the one being action rate for preventing dog attacks on koalas by dog owners and with the other being consciousness of local people including both dog owners and

non-dog owners. In terms of government policy, whether dog management for protecting koalas is effective or not was discussed based on dog owners' action rate and local people's consciousness. If the dog owners' action rate and local people's awareness for the prevention of dog attacks is high, the policy is regarded as effective and as not in the reverse case. Furthermore, as one of the policies on government on dog control, locations and messages of signs were studied. Finally, characteristic of distributions of dog attacks on koalas at macro scale and results of field surveys on awareness and government policy at micro scale were synthesized and lead to a suggestion for prevention of dog attacks on koalas.

Data collection and maps

Geographical data on dog attacks on koalas with the year of the event was extracted from two different data sources in 2014 from NSW Atlas and open crowdsourced database, Koala Tracker map (http://www.koalatracker.com.au/). Then data on land use in mesh blocks in 2011 and rural and urban categories in Section of State (SOS) in 2011 from Australian Bureau of Statistics was added to extracted data and maps of dog attacks on koalas was made using ArcGIS.

Moreover, the labeling of urban and rural categories were changed as below (Table 3)

The level of urban is higher in Major Urban, Other Urban, Bounded Rural, and Other Rural in this order.

Table 3 Labeling of urban and rural types

SOS name	Major Urban	Other Urban	Bounded Localities	Rural Balance
This research			Bounded rural	Other rural

Study area

Along with mapping of distributions of dog attacks on koalas in Australia, field surveys at Lemon Tree Passage in New South Wales was conducted to assess awareness of local people including dog owners and non-dog owners. Lemon Tree Passage is in the northeastern edge of the Port Stephens local government area in the hunter region, which is 194 km north of Sydney and 47 km northeast of Newcastle (Figure 1). Its area is 1.8km^{2}with 2534 populations in 2011 by the boundaries of Urban Centres and Localities by Australian Bureau of statistics which is the most valid for the field surveys range conducted.

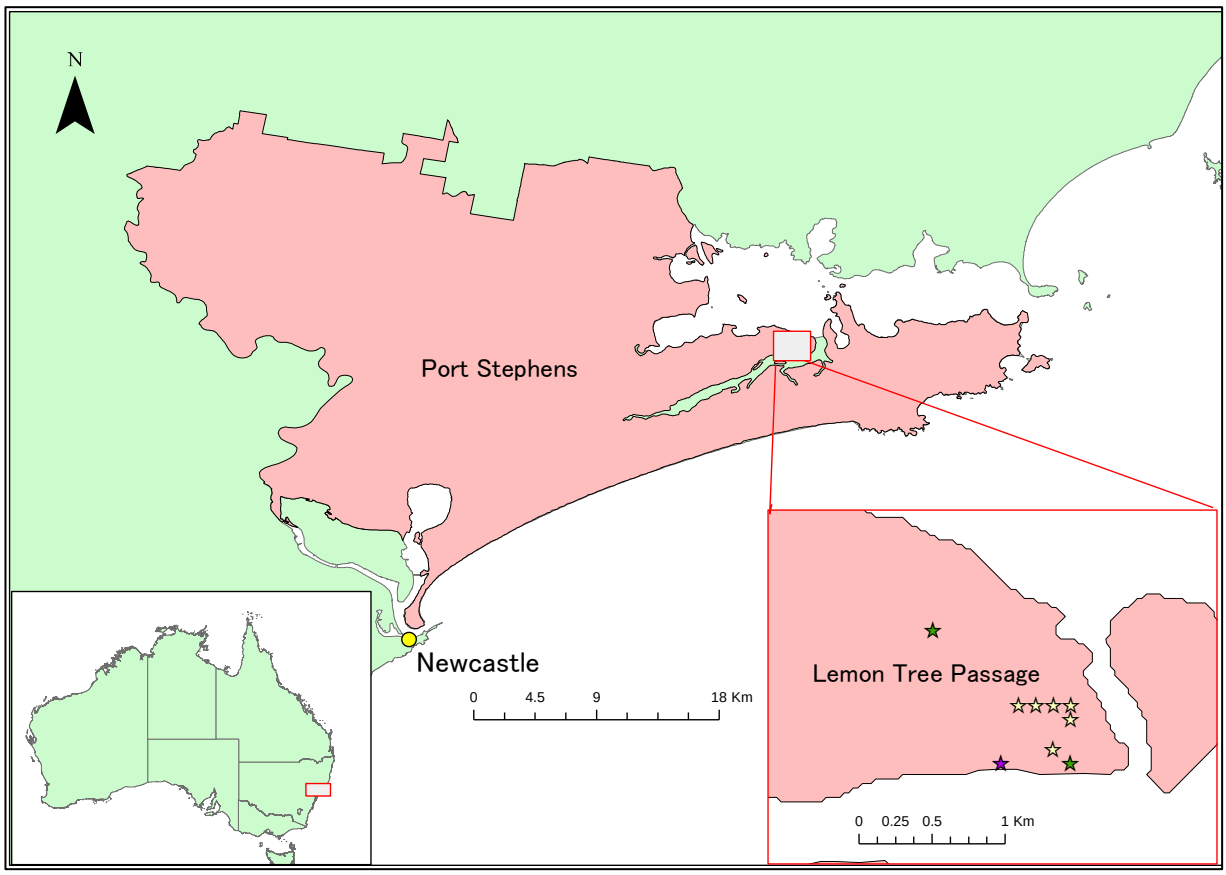

Figure 2 Lemon Tree Passage in Port Stephens

Lemon Tree Passage was selected as a study area from three reasons. Firstly, dog attacks on koalas have found to be a crucial cause of koala mortality in Port Stephens where lemon Tree Passage is located (Lunney et al, 2004). Moreover, Lunney et al (2007) also conclude that reducing the mortality is essential to maintain koala populations at this area. Thus, prevention of the dog attacks at this site should be sought. Secondly, the number of dog attacks on koalas in Lemon Tree Passage was by far the highest among all statistical area level 2 (SA2) with 21 records, followed

greatly behind by the second with only 10 records, (Table 4). Williamstown, which also belongs to Port Stephens local area, ranks in the top three by the number of dog attacks records, indicating Port Stephens to have frequent dog attacks on koalas as suggested by Lunney et al (2004)

However, their last record in Lemon Tree Passage was in 1991, and this may reflect decline of dog attacks on koalas along with reduced awareness and less emphasized local policy on them.

Table 4 Records of dog attack on koalas by suburbs

SA2 Areas	Dog Attack Records	Port Stephens	State
Lemon Tree Passage - Tanilba Bay	21	○	NSW
Happy Valley	10		SA
Williamtown - Medowie - Karuah	10	○	NSW
Aberfoyle Park	9		SA
Esk	7		QLD

Thirdly, dog attacks distributions in Lemon Tree Passage were the most concentrated compared to all other areas. The high density of dog attacks would facilitate following field surveys.

Some pictures at Lemon Tree Passage are presented below.

Photo 1 A sign warring road kills of the koalas

(Photographed by K. Arai, November 2014)

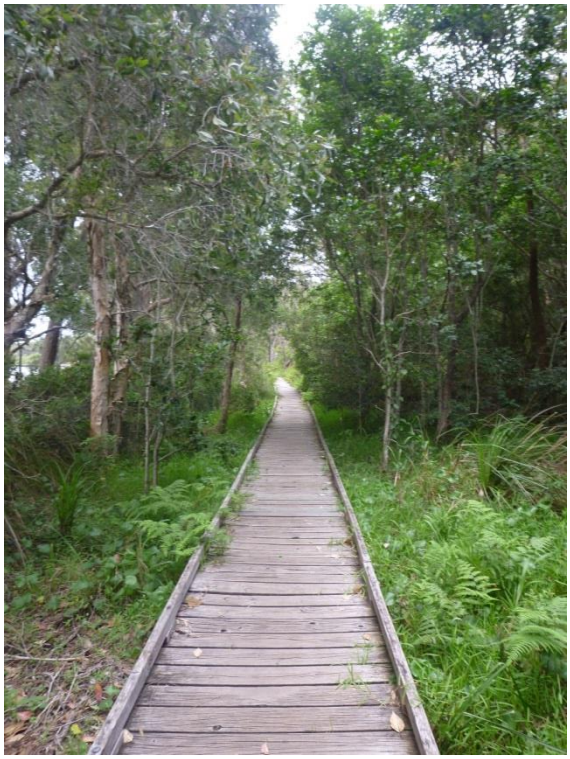

Photo 2 Forests areas in the lemon tree passage

(Photographed by K. Arai, November 2014)

Photo 3 Wild p**elicans** at the port

(Photographed by K. Arai, November 2014)

Photo 4 A dog park along the port

(Photographed by K. Arai, November 2014)

Photo5 On the wall of a local club in Lemon Tree Passage, saying “The Koala Capital of Port Stephens”
(Photographed by K. Arai, November 2014)

Distributions of dogs and signs

To know where dogs are present and how they are kept by dog owners, the locations of dogs in Lemon Tree Passage were mapped by walk for three days from 29th to 31th November in 2014. Each household was visited once per day and three times in total at different times from morning (from 7am to before 12am), daytime (from 12am to before 6pm), to evening (from 6pm to 9pm) each. Dogs were labeled as 'Outside', 'Balcony' (on the second floor), 'Inside' if observable and 'Barking' if only barking was head without sightings (unsure about the location). The status in two or more days was adopted. As an assessment of policy, locations of signs related to dogs were also recorded to see if their locations relative to dogs and koala habitats, and messages were appropriate.

Dog attacks risk

Based on the three main factors that have found to heighten the chance of dog attacks, their risk was categorized into 4 groups from 'Very high', 'High', 'Moderate', to 'Low' depending how many factors the dogs have. The factors include (1) whether they are kept out at night, (2) large dogs, and (3) multiple dogs (P. Smith& Smith, 1989; McAlpine et al, 2006; QLD EPA, 2006b; QLD DEHP, 2008, NRMMC, 2009). Dogs were labeled as

‘Outside at nigh’ if they were outside at night for two days or more out of three.

On-the-street questionnaire

To assess the level of awareness and actions to dog attacks on koalas, 13 questions on general concern for koalas, threats to koalas, whether respondents have seen information on dog attacks on koalas and its source, their actions to prevent dog attacks on koalas, education of dog attacks on koalas by council, and effective measure for their preventions were interviewed. Additionally, how often respondents see free-roaming dogs were also asked to see if dogs including wild and domestic dogs are controlled properly. This is because free-roaming dogs especially attack koalas in forests and they are often unreported (Lunney et al, 1999; NSW NPWS, 2003; Phillips et al 2011). The questionnaire survey was conducted around Lemon Tree Passage post office between 9am to 5pm from 26th November to 3th December by asking people on the street randomly.

Assessment of koala plans in Port Stephens

To know the situation of dog management for koala conservation in detail, comments from the Port Stephens Council on 13 actions in the Port

Stephens Council Comprehensive Koala Plan of management (CKPoM) were collected through an email. In particular, the questions included how much effort the Port Stephens Council put on each action, its effect and challenges. The CKPoM corresponds to the National Koala Strategy (ANZECC1998) in that it aims to conserve koalas by protecting their habitat and integrating koala conservation into local government planning process (Lunney et al, 1998).

3. Distributions of dog attacks on koalas in Australia and their regional difference

3.1 Overview of the data on dog attacks on koalas

The data from New South Wakes Atlas (Atlas) and the Koala Tracker (Tracker) were significantly different in terms of year range and the number of records (Table 5). Atlas has records from 1973, while Tracker ranges from 2002 and the number of record is by far higher in Tracker than that in Atlas with 136 and 44 respectively.

Year	Atlas	Tracker	Total
1973	2	0	2
1977	1	0	1
1979	1	0	1
1980	1	0	1
1983	1	0	1
1988	1	0	1
1989	5	0	5
1990	4	0	4
1991	14	0	14
1992	9	0	9
1993	1	0	1
2001	1	0	1
2002	0	11	11
2005	0	1	1
2007	0	1	1
2008	1	0	1
2009	0	2	2
2010	1	9	10
2011	0	22	22
2012	0	61	61
2013	1	29	30
Total	44	136	180

Table 5 The number of dog attacks records by year

Source: NSW Atlas and the Koala Tracker in 2011

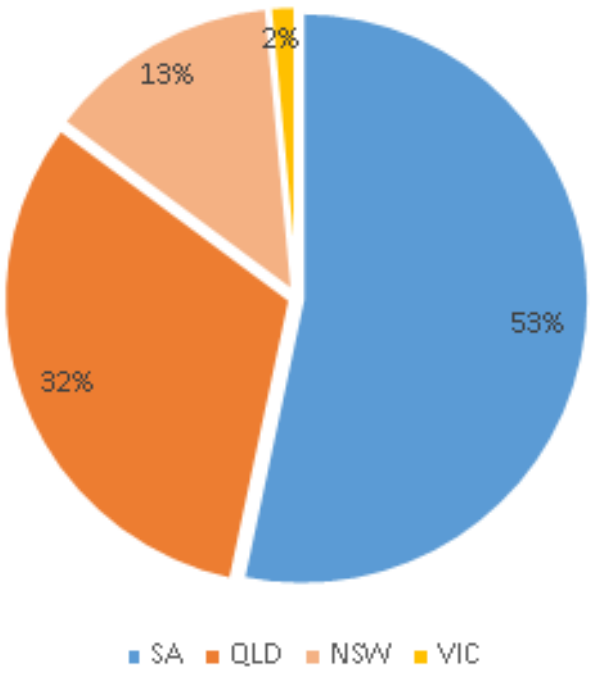

Figure 3 The dog attacks recordsby states(N=44)

Source: Koala Tracker

As for the Tracker, the records from two states were dominant with South Australia(SA) consisting 53% of all records and QLD accounting for 32%.

3.2 Distributions of dog attacks on koalas in Australia

The distributions of dog attacks on koalas were mapped using combined data from Atlas and Tracker (Table 5) and they were dispersed in four different states from Queensland (DLD), New South Wales (NSW), Vitoria (VIC), and South Australia (SA) (Figure 4). Firstly, two distribution patters were found with one being concentrating in major cities with the other being relatively dispersed around the main city. For example, in SA, VIC

and NSW, their distributions gather around a major city or cities in the state.

This distribution pattern with high density of dog attacks in populated area is consistent with a theory oh more dog attacks in urban areas than in rural areas, drawn from McAlpine et al (2007) and Acosta-Jamett et al (2010) (more in Introduction). However, its explanatory variable is dog densities, which this map does not take account into considerations. Thus, this map cannot relate dog densities to dog attacks frequency, but the tendency of dog attacks concentrating around populated city has been demonstrated. On the other hand, in QLD, their distributions are widely dispersed around a large city, Brisbane. Further research on this is in the next section.

Secondly, recent dog attacks take place more in QLD and SA than in NSW and VIC although bias of data would have influenced on this result.

Table 6 The combined data on dog attacks on koalas

Year	NSW	QLD	SA	VIC	Total
1973	2	0	0	0	2
1977	1	0	0	0	1
1979	1	0	0	0	1
1980	1	0	0	0	1
1983	1	0	0	0	1
1988	1	0	0	0	1
1989	5	0	0	0	5
1990	4	0	0	0	4
1991	14	0	0	0	14
1992	9	0	0	0	9
1993	1	0	0	0	1
2001	1	0	0	0	1
2002	11	0	0	0	11
2005	1	0	0	0	1
2007	1	0	0	0	1
2008	1	0	0	0	1
2009	2	0	0	0	2
2010	1	8		1	10
2011	1	14	7		22
2012	2	12	46	1	61
2013	2	9	19		30
Total	63	43	72	2	180

Source: NSW Atlas and Koala Tracker

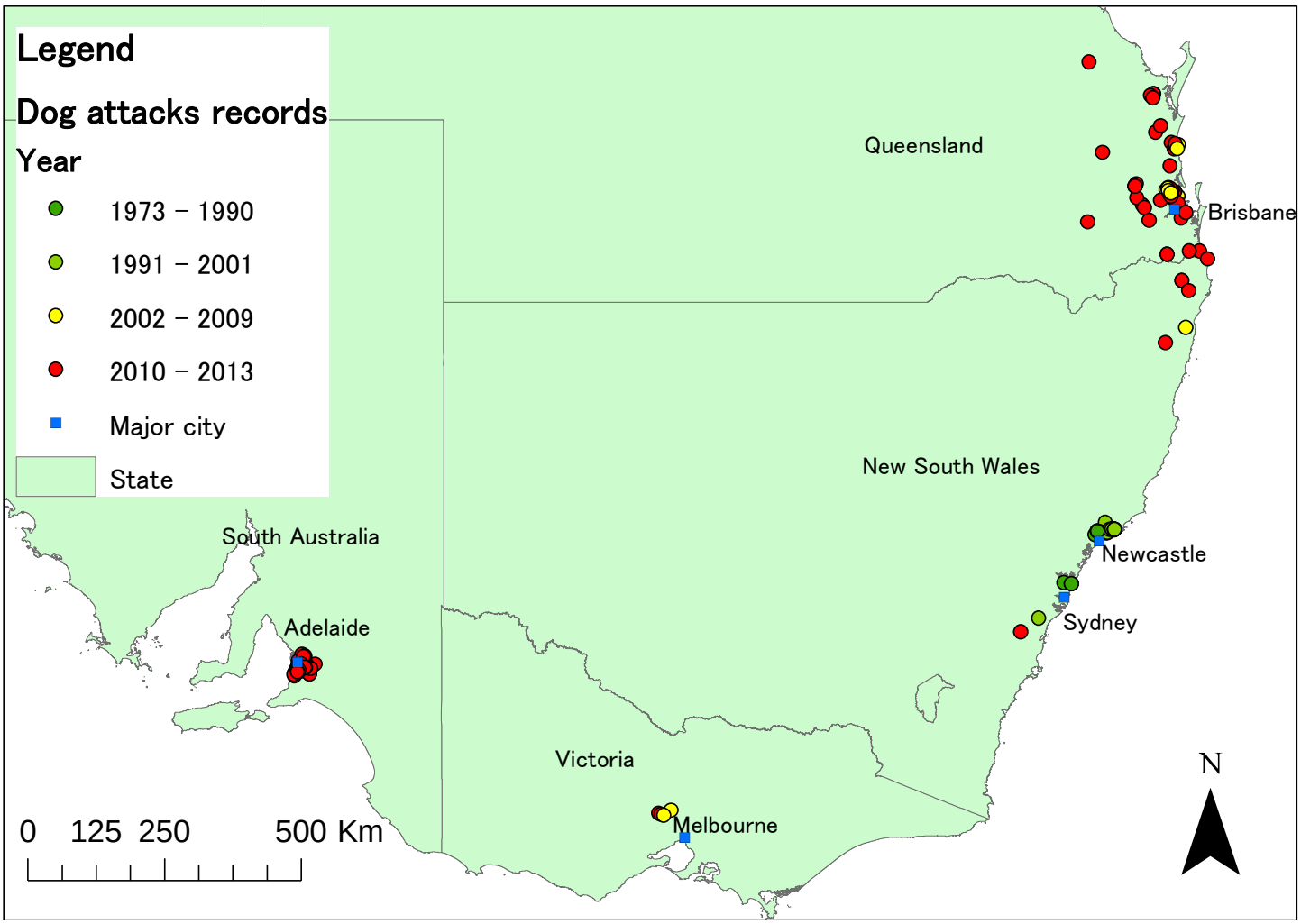

Figure 4 Distributions of dog attacks in Australia

Source: NSW Atlas and the Koala Tracker in 2014, June

3.3 Distribution pattern by land use in SA and QLD

To investigate the distribution patters more in detail, SA and QLD were selected as targets because the number of records between 2010 and 2013 were significantly higher than other two states (Table 6). Because the year when the land use map was based on should correspond to the years when

dog attacks took place, they year of 2011 was the most appropriate, compared to 2006, and 2001 when little record was available

Distributions by land use in SA

Firstly, most dog attacks on koalas take place in residential areas, that is, suburbs of Adelaide. Especially, in Area 1(Figure 5) where parkland is surrounded by residential areas, dog density is high and the records of all years are included. This may have something to do with the parkland in the center of area1. Secondly, in 2013, some records in the south and the north spread to outward away from Adelaide where no record in 2011 and 2012 is around. Thirdly, in certain areas, such as Area 2 and Area 3(Figure , attacks are repeated, suggesting the hotspots where strict dog management should be put on. Finally, the range of this map corresponds to the highest habitat suitability area for koala occurrence across SA, based on generalized linear mixed-effects models derived from citizen science (Sequeira et al, 2014). Not only may the probable high dog density in populated area around Adelaide, koala occurrence may also influence the density of dog attacks on koalas.

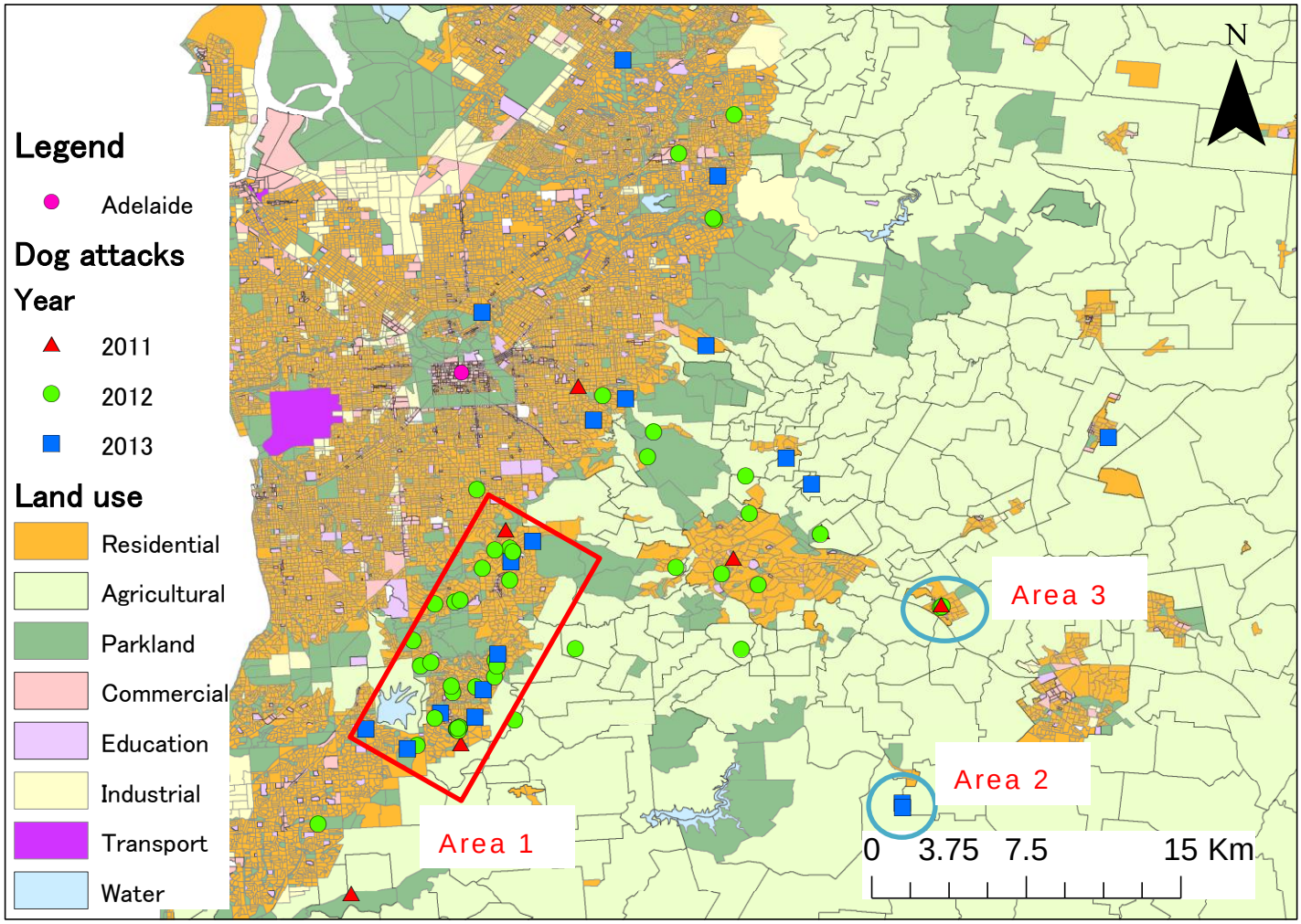

Figure 5 Distributions of dog attacks on koalas by land use in SA

Distributions by land use in QLD

Dog attacks records are widely dispersed from the south-east Queensland to inland as opposed to SA where their records are particularly concentrated around Adelaide. The difference of map scale with SA being large and with QLD being by far small also shows the level of concentrations or dispersion.

The records around Brisbane shows similar pattern to those in Adelaide in SA in that they locate not in proximity in the major city but in its suburbs. In inlands, dog attacks tend to occur in parklands or agricultural land which is harder to detect, compared to those happening in populated residential areas around the Brisbane

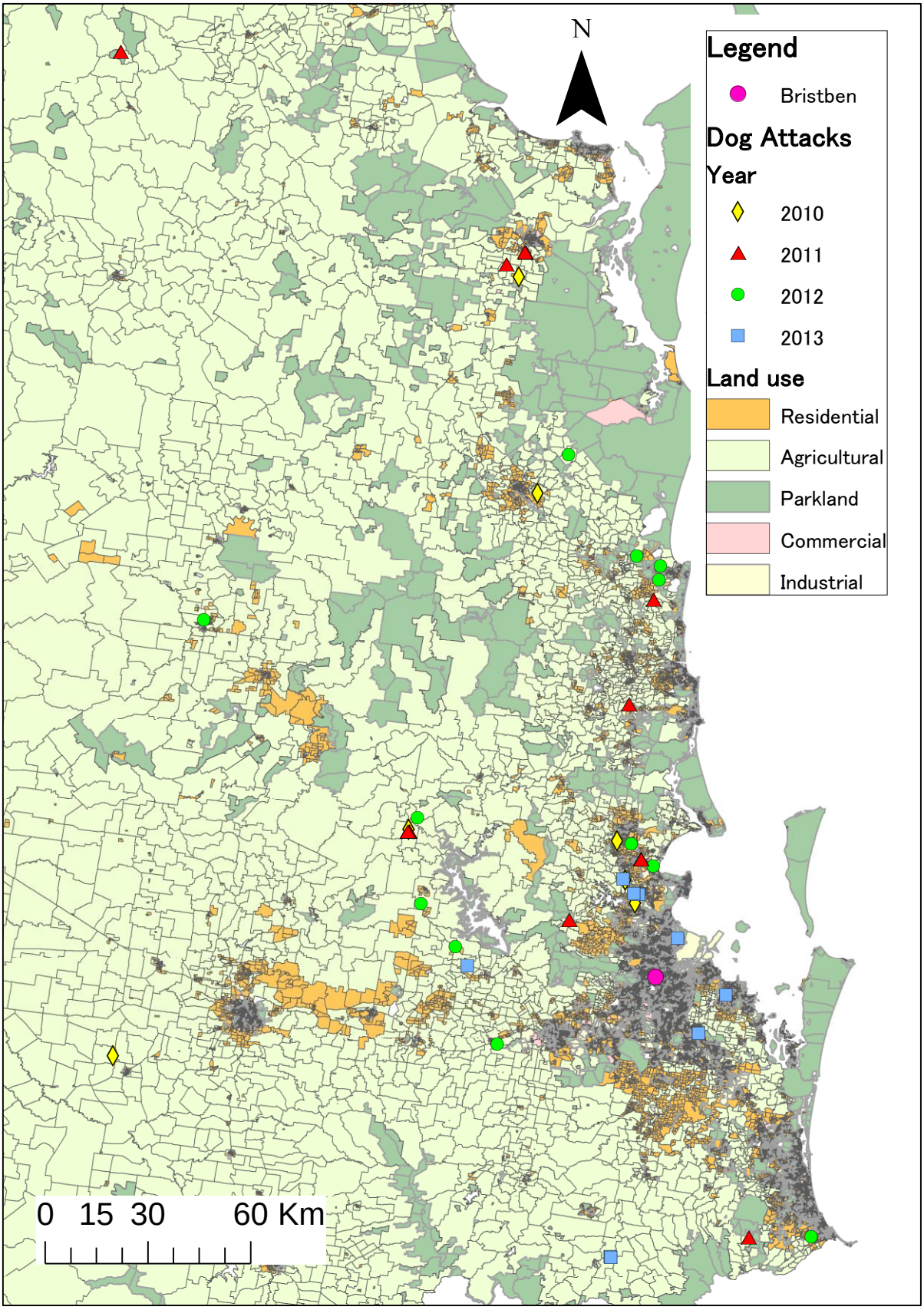

Figure 6 Distributions of dog attacks on koalas by land use in QLD

3.4 Distribution pattern in urban and rural areas in SA and QLD

Distributions in urban and rural areas in SA

Firstly, most of dog attacks occurred in major and other urban areas with them making up for at least 70% of all dog attacks records in SA each year. Secondly, the records in rural areas are adjacent to urban areas both in suburbs of major urban around Adelaide and in the inland suburbs of other urban areas.

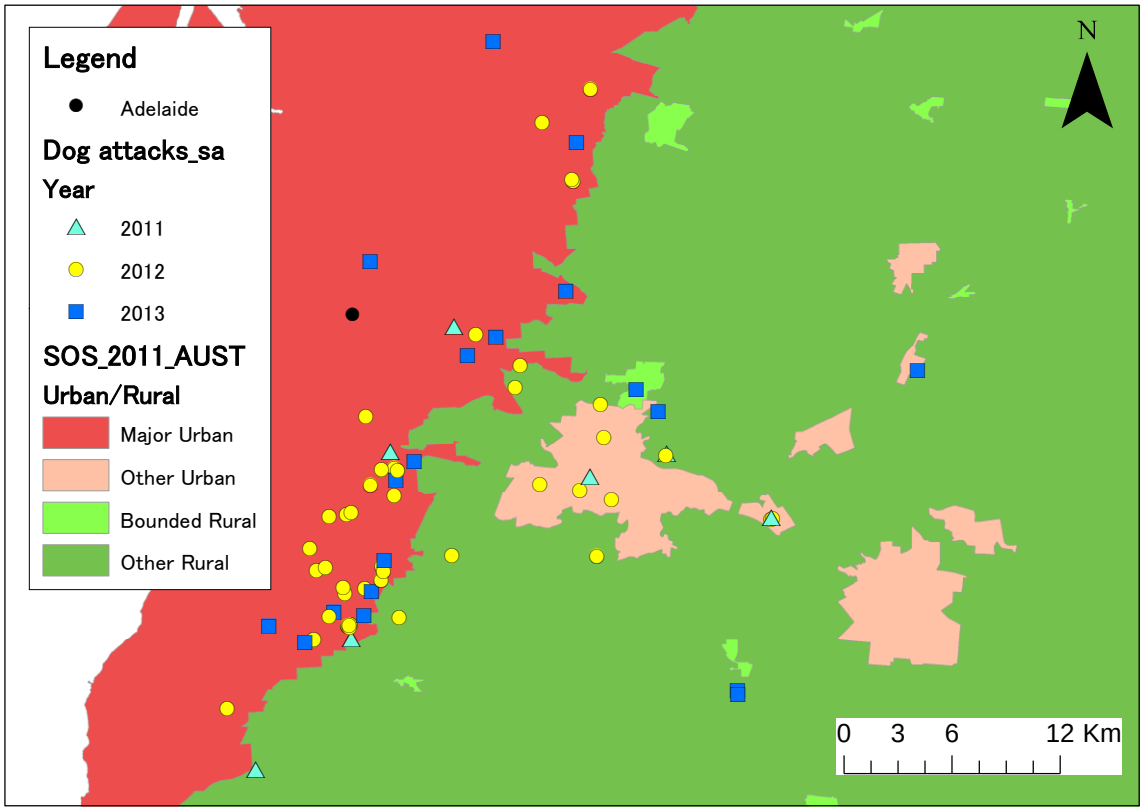

Figure 7 Distributions of dog attacks on koalas by urban and rural sections in SA

Distributions in urban and rural areas in QLD

In contrast with the distributions in SA where records' number are consistently high in urban areas, dog attacks in QLD took place more in rural areas (Figure 8). What is more, relatively large proportions of records locate even on the areas that are far away from urban areas around Brisbane. Additionally, the records in rural areas reveal the similar pattern to those in SA in that the records in inlands are often in the vicinity of other urban areas (Figure 7, 8)

However, their proportions to all records in QLD changes widely by year from 44% in 2013 to 75% in 2010. But this large change in proportion largely results from small sample size, there is no difference in proportions by years as a whole, based on the Fisher's exact test.

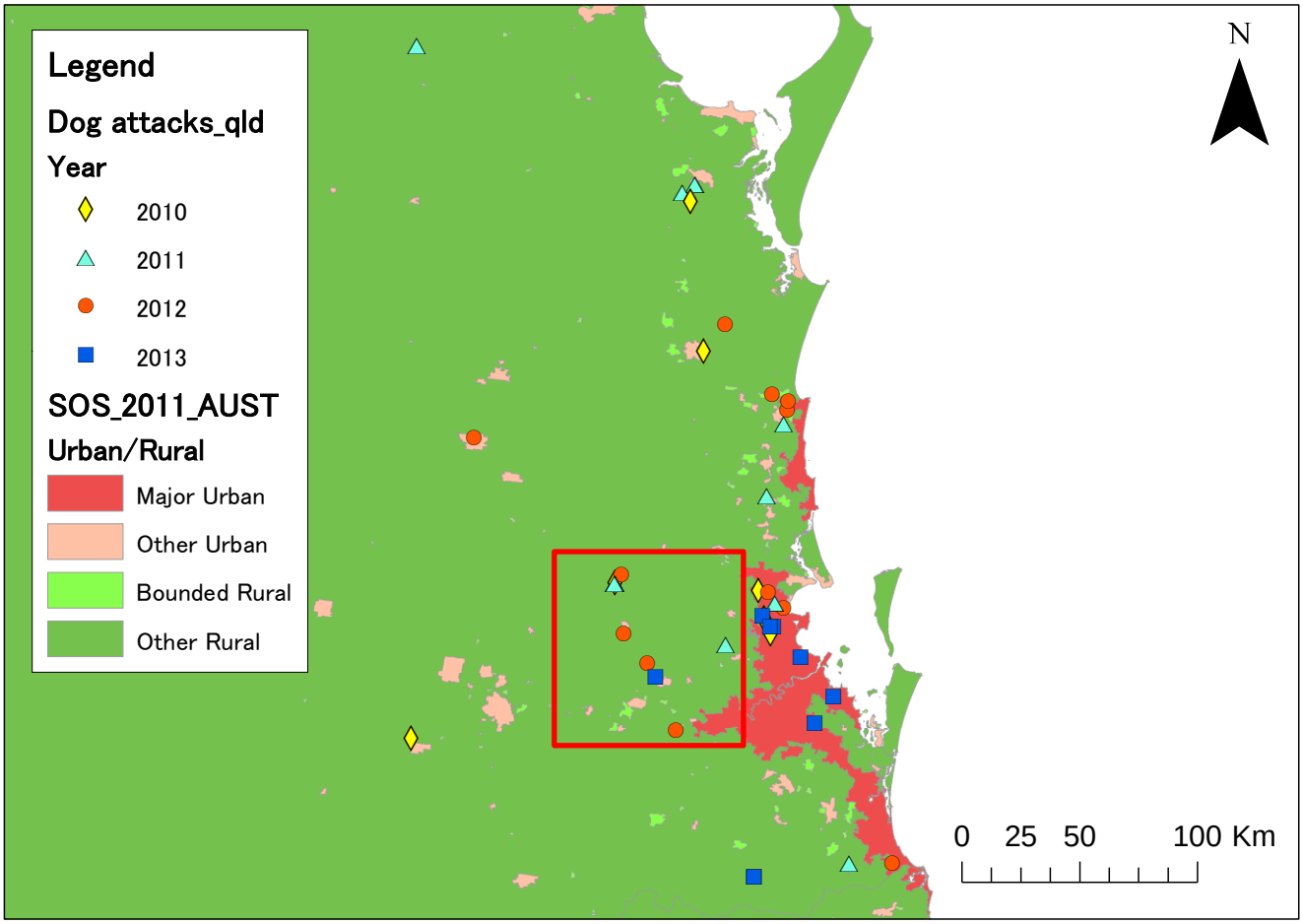

Figure 8 Distribution of dog attacks on koalas by urban and rural sections in QLD

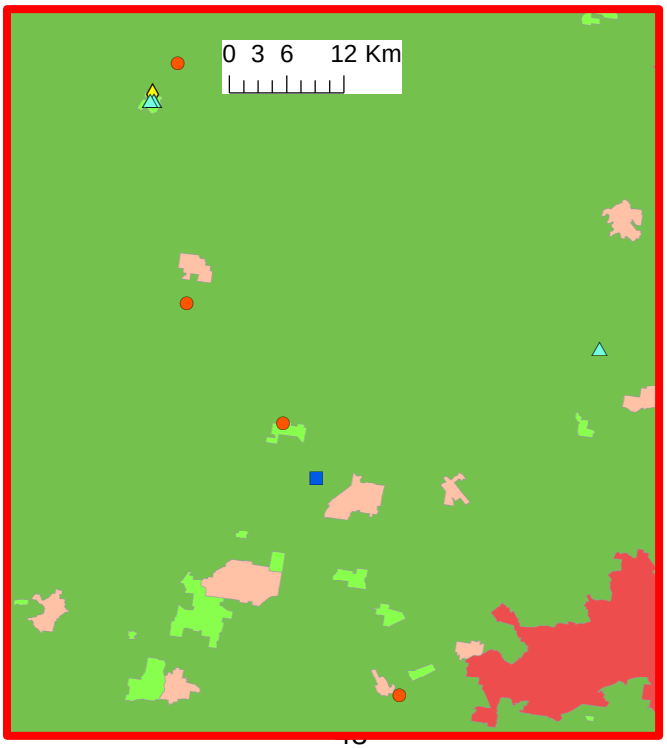

Figure 9 A detailed map in inland in QLD

3.5 Statistical comparison of the distributions in SA and QLD

Land use

The number of dog attacks on koalas by land use in SA and QLD is summarized as below (Table 5).

Table 7 Breakdown of dog attacks on koalas in SA and QLD

	Agricultural	Commercial	Education	Parkland	Residential	Total
QLD	4	1	0	5	33	43
SA	5	5	1	3	58	72
Total	9	6	1	8	91	115

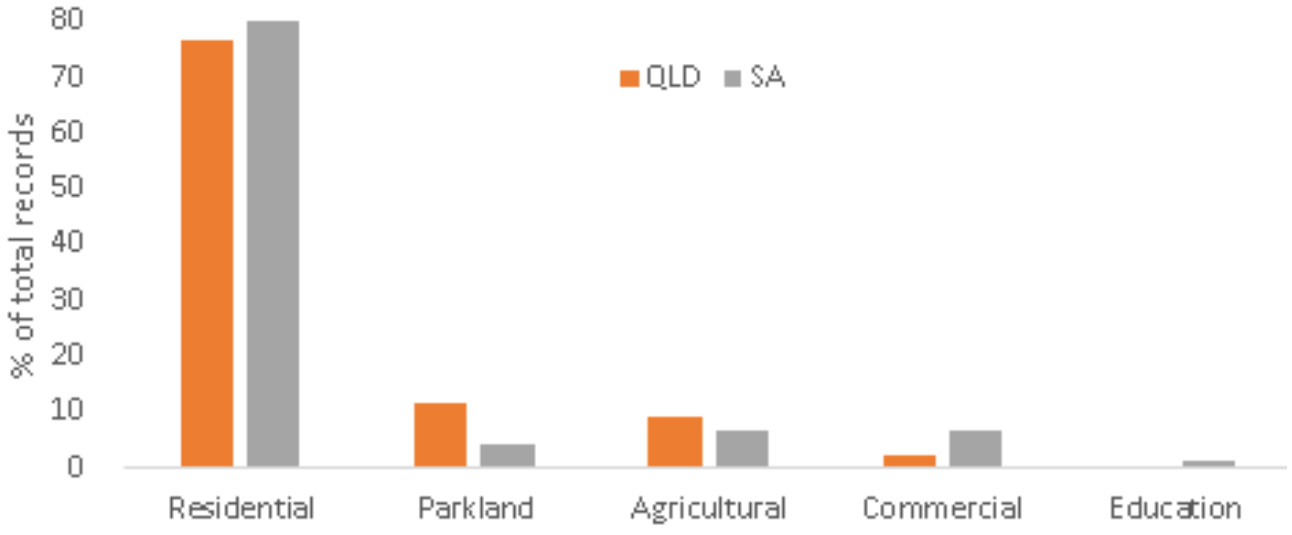

Figure 10 The percentage of dog attacks on koalas by land use

Source: Koala Tracker

Table 8 Differences of percentages on residential areas Fisher's exact test

	residential	Parkland	Agricultural	Commercial	Education
Residential	-				
Parkland	**	-			
Agricultural	**	n.s	-		
Commercial	**	n.s	n.s	-	
Education	**	n.s	n.s	n.s	-

**p<0.01

Firstly, both in SA and QLD, the proportion of dog attacks that happened in residential area is higher than any other land uses (Table 7), based on Fisher's exact test(N=72 in SA and N=43 in QLD, $p < 0.01$ in both**)**. Fisher's exact test was adopted instead of chi-square test according to Cochran's rule. Secondly, Fisher's exact test also shows that there is no difference between SA and QLD in the proportion of each land use where dog attacks occurred.

Urban and rural areas

The number of dog attacks on koalas in urban and rural areas in SA and QLD is summarized as below (Table 9)

Table 9 The number of dog attacks by urban and rural sections

	Major Urban	Other Urban	Bounded Rural	Other Rural	Total
QLD	14	2	6	21	43
SA	51	10	1	10	72
Total	65	12	7	31	115

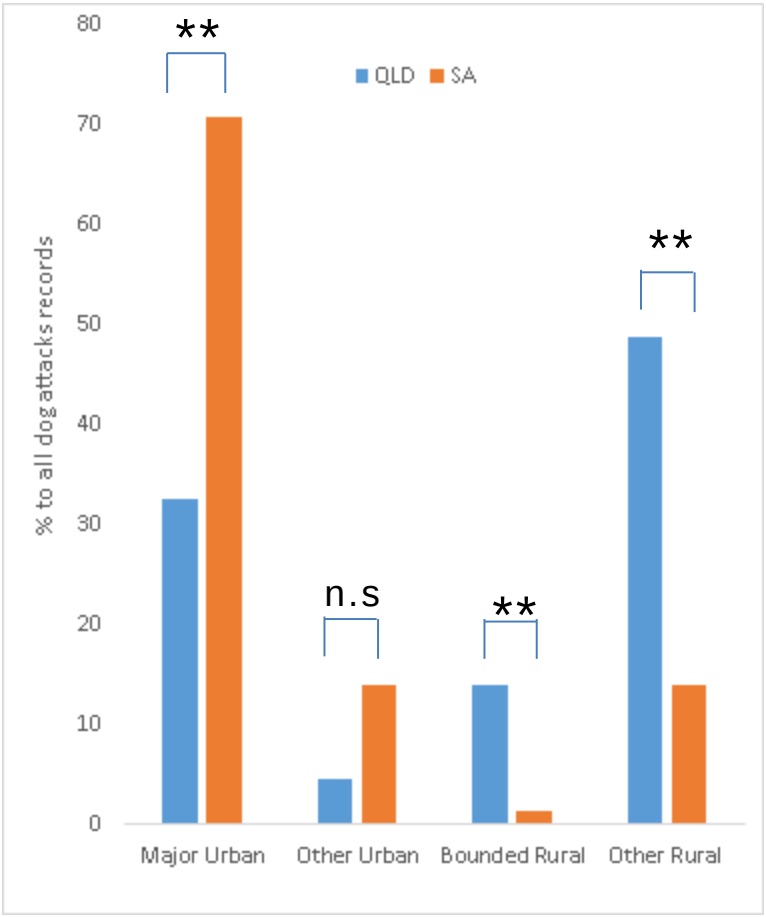

Figure 11 Difference of percentages of dog attacks on koalas occurred by urban and rural sections

Table 10 The difference in QLD and SA in the proportion of dog attacks ae each category

State	Major Urban		Other Urban	Bounded Rural		Other Rural	
QLD	**	▽	n.s	**	▲	**	▲
SA		▲			▽		▽

**P<0.01

Fisher's exact test revealed differences in proportions of dog attacks on koalas in three categories between SA and QLD (N=43 in QLD and N=72 in SA, P= 1.60527e-06<0.01) (Figure 11, Table 10). In detail, the proportion of dog attacks on koalas in Major Urban is higher in SA than in QLD. On the other hand, the proportions of Bounded Rural and Other Rural are lower in SA than in QLD. This results show that where dog attacks on koalas take place is different in SA and QLD with SA in large urban areas with QLD in rural areas. These patterns cam be also judged visually (Figure 7, 8).

4. Characteristics of dogs and signs in Lemon Tree Passage

4.1 Distributions of dog attacks on koalas in the past

Historical distributions of dog attacks on koalas, dog presence, and locations of signs related to dogs are shown in the Figure 12 below.

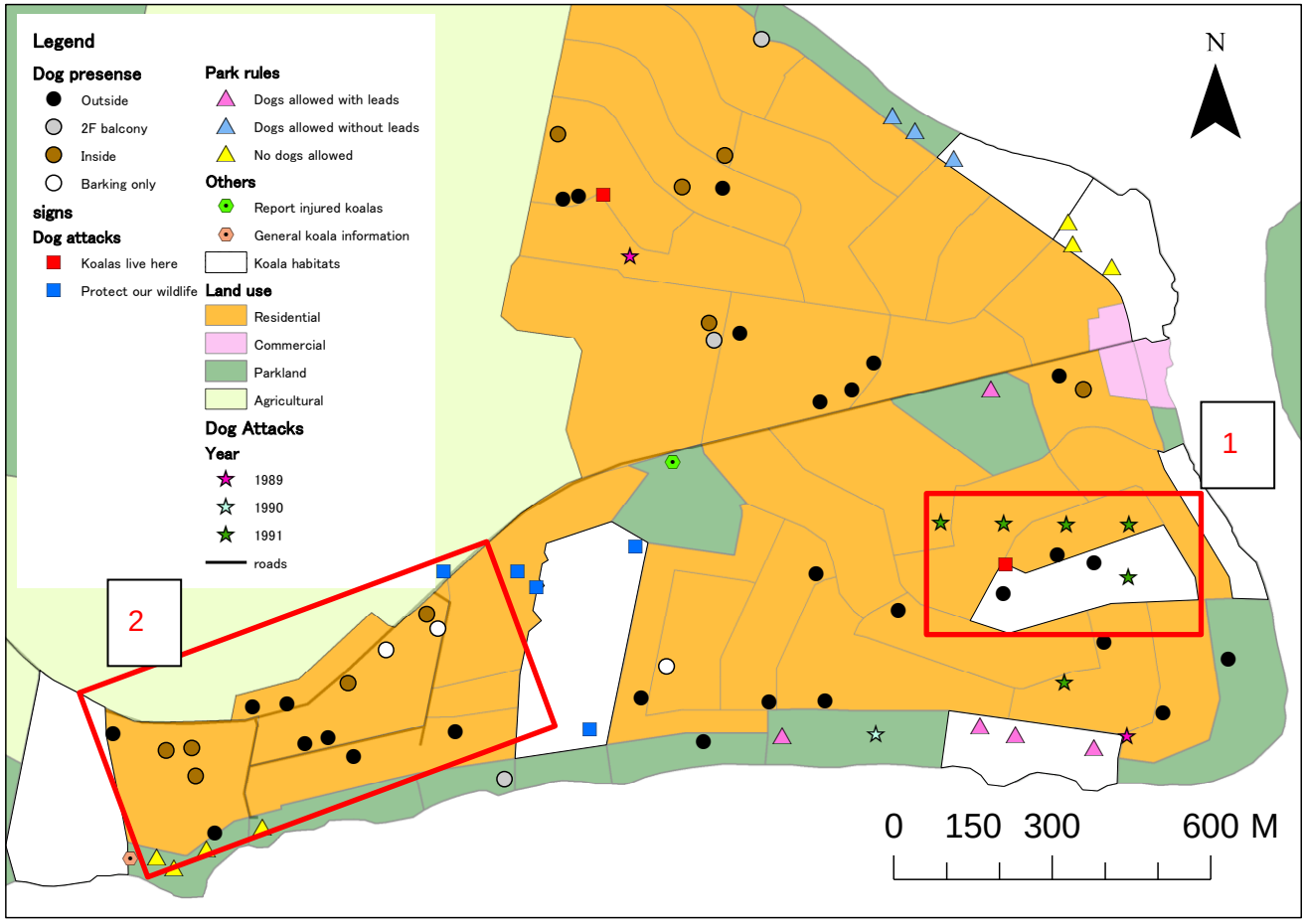

Figure 12 Distributions of dog attacks on koalas

Source: Field survey

9 dog attacks are recorded between 1980 and 1991 in the lemon tree passage and they are distributed unevenly with the concentration around the koala habitat1 (Number 1 in Figure 12). In 2011, this habitat area is already developed and is categorized as residential area, but it still has some forests and falls into koala habitat in a field survey. The habitat1 is the only habitat area that are completely overlapped with and surrounded by residential areas, while other habitat areas are partly adjutant to residential areas and located on parklands with forests.

4.2 Dog presence

Spatial distribution

44 dogs were observed and they ranged more in the south above the main road than in the north as shown in the historical records of dog attacks with 8 records in the south and only one in the north. Again, dogs are aggregated around the koala habitat1 as dog attacks were, and this area is considered to be hot spot of dog attacks on koalas as its habitat is on residential area where more pet dogs exist than non-residential area. Dog concentrated areas are across the lemon tree passage and those in west side of the south are located between koala habitats. Although no dog attacks records was found in 1980 and 1991 in this area, this range seems to be the second hot spot

(number 2 in the Figure12) that has high potential of dog attacks on koala considering high dog density in relatively small area surrounded by koala habitats and forest.

Where dogs are

A summary of dog status are below (Table 10)

Table 11 The number of dogs by where they were

Where is the dogs	Observed number of dogs
Outside in the morning and daytime	28 (63.6%) 13(29.5%) at night as well
2F Balcony	3 (6.8%)
Inside	10 (22.7%)
Unsure(Barking only)	3 (6.8%)
Total	44

Source: Field survey

The most common place of dogs was outside and it accounts for as much as over 63% of all observed dog (Table 11). Moreover, almost half (46%) of dogs outside in the morning and daytime remained outside even at night when dog attacks on koalas often take place (QLD EPA, 2006b). There is still room for encouraging all dog owners to keep their dog outside at night.

Additionally, no dog kept outside was on a lead but they were in enclosed yards with fences instead. To avoid dog attacks on koalas, either confining dogs with fences or keeping dogs on a lead is required(QLD EPA, 2006; QLD DEHP, 2008). Therefore, most dog owners in the lemon tree passage follow the basic rule for avoiding dog attacks on koalas, whether intended or not, except for keeping dog inside at night.

The second and the third common place for dogs was inside the houses and at a balcony on the second floor respectively, which has little risk on dog attacks on koalas. The status of three dogs was not identified because only their barking was heard with no observation.

4.3. Distributions of signs related to dogs

A summary of signs observed in the lemon tree passage is in the table below (Table 12).

Table 12 Signs related to dogs in Lemon Tree Passage

Audience	Topic	Key message	Dogs on lead	Dogs to be fenced in at night	Place	No. of signs	Total
Dog owners	Dog Attacks	Koalas live here	●		Small residential streets	2	8(33%)
		Protect our wildlife	●		Forests	5	
		Koala share their backyard with us	●	●	Reserve area	1	
General public	Road Kills	-Injured koalas call XXXX -Koala cross here			A main road	1	1(4%)
	Park Rules	-Dog allowed with lead -Dog allowed without lead -No dog allowed			Parks	5 3 7	15(63%)
						24	

Source: Field survey

Photo 6 A sign asking dogs on lead for to koalas

(Photographed by K. Arai, November 2014)

Photo 7 A sign asking dogs on lead for wildlife

Photographed by K. Arai, November 2014)

(

Photo 8 The sign asking dogs on lead for to koalas at the Mungarra reserve

(Photographed by K. Arai, November 2014)

Photo 9 The information board on koalas at the Mungarra reserve

(Photographed by K. Arai, November 2014)

Photo 10 A sign for koala reporting alongside Lemon Tree Passage Road

(Photographed by K. Arai, November 2014)

Photo 11 A sign informing koala reserve in front of Mangrove Boardwalk

(Photographed by K. Arai, November 2014)

Photo 12 At Mangrove Boardwalk

(Photographed by K. Arai, November 2014)

Photo 13 A sign of park rules where dogs are allowed on lead (Photographed by K. Arai, November 2014)

4.3 Signs and their features

Two types of signs

The observed signs seemed to target two different audiences with dog owners and general public including dog owners and non-dog owners. As for the signs for dog owners, the main message was to keep their dog on lead but two different types were found with the one specifically focusing on koalas and the other on wildlife in general. The signs designed only for koalas indicated the significance of preventing dog attacks on koalas.

With regards to signs targeted for general public, one was about general koala information, other was about dog permissions as a part of park rules, and the other was for reporting for injured koalas, in particular, those hit by vehicles given that the sign was alongside the main road.

The signs for park rules made up for over 60% of observed signs as several of them were placed per park. However, among the rest of 9 signs, 8 signs were on dog attacks and only one sign was on road kills, even if it is the biggest cause for declining number of koalas. This suggests that dog attacks on koalas can be prevented with signs more effectively than road kills as it largely depends on dog owners. (Port Stephens Council (2002) also argues that the most effective way to prevent dog attacks in to promote responsible dog ownership in their koala management plan.

However, based on messages on signs, they seem to be ineffective because they do not completely deal with the dog attacks on koalas at night at dog owners' yard, which is the most case of the attacks. Instead, they signs sorely appeal to keep dog on a lead, which is not the most common case of dog attacks. For example, out of 8 signs on dog attacks on koalas, only one sign mentions dog attacks at night but it is still inadequate because its message asks dog owners only to keep their dog in fence rather than inside the house. If "fenced in" means putting dog in a closed cage that the dog cannot widely move around, it is almost equivalent to keeping dog inside. Thus, dogs cannot chase or bite koalas almost 100% and this action will prevent dog attacks on koalas. However, in the field survey of this research, no households with a dog have such an enclosed cage. Instead, they had fence around their yards and their dogs were free to roam within the enclosed yard. If letting dog move freely in an enclosed yard with fence at night means "dogs to be fenced in at night", it will not prevent dog attacks on koalas. Moreover such an unclear message as a sign itself shows the ineffective communication. Alternatively, the message "Keep dog inside at night" will be better in in preventing dog attacks on koalas at night at dog owners' yard, which is the major case of attacks. Also, this simple action is what previous research recommended (QLD EPA, 2006b; QLD

DEHP, 2008). Additionally, not only signs but also other approach that facilitate dog owners keeping their dog inside at night should also be sought.

However, 5 out of 35 respondents interviewed mentioned that the existence of any signs related to koalas make them realize that koalas live in the areas. However, those signs will not automatically cause them to take action, which would actually help koalas. Thus, effective messages on sighs that cause people to take actions should be encouraged.

Spatial distribution of signs

The signs that sorely focus on koalas were placed along with small residential street sign, whereas those on wildlife stood separately as itself in koala habitat or forest areas. This suggests that the former in particular targeted for residents living or waking around the street in contrast to the latter for those walking their dogs in forests. Additionally, the all five wildlife signs located only in the one habitat area and none was in others. This implies that this habitat area may be in particularly important in wider wildlife.

With regard to park rules, most of dog permissions fitted for koala habitats so that no dogs or only on-lead dogs are allowed close to the koala

habitats. However, small part of off-leashed dog park went across the koala habitat in the north.

Moreover, even in the area where dogs are not allowed, some dog owners walked their dogs without leads.

Therefore, more careful investigation on determination of off-leashed dog parks and strict dog control at parks are needed.

Relationship between signs and dogs

The two signs specific to koalas locate close to households having dogs and the one in the south also has the koala habitat nearby. However, neither when those signs were set up nor since when those dog owners have dogs is unknown. Nevertheless, as for the sign adjoining to the koala habitat, government is considered to take account this area in setting the sign because the message “Koalas live here” indicates their habitats.

4.4 Dog attacks risk

Breakdown of the dog attacks risk

33 records that all three factors below are available were labeled regarding dog attacks risk (Table12). If there is more than one dog, higher risk was

adapted. For example, if there are a small and large dogs, “large dogs” is counted.

Table 13 Dog attacks risk at each dog

Outside at night	Large dogs	Multiple dogs	Risk	No. of dogs	Total
●	●	●	Very High	1 2.3%	1 2.3%
●	●		High	5 11.4%	11 25%
	●	●		2 4.5%	
●		●		4 9.1%	
●			Moderate	3 6.8%	10 22.7%
	●			4 9.1%	
		●		3 6.8%	
-			Low	11 25%	11 25%
NA	NA	NA	Unknown	11 25%	11 25%
Total				44	

Although the property with very high risk of dog attacks is only one, half of dog owners at least have one factor that heighten the likelihood of dog attacks. The factors about dog size and numbers are hard to eliminate immediately for dog owners because they need to change their dogs. However, another factor concerning keeping dog inside at night can be easily removed by a little change of habit. For example, 9 dogs out of 11 fall down to ”Moderate” from “High risk” just by getting keeping dog outside out night. The low rate of dog owners keeping their dog inside at night seems to come from the lack of its information and education.

Spatial distribution of dog attack risk

Based on the table above, distributions of dog attacks risk were visualized (Figure 13).Firstly, the spatial distributions of dog attacks was summarized and then its discussion was continued.

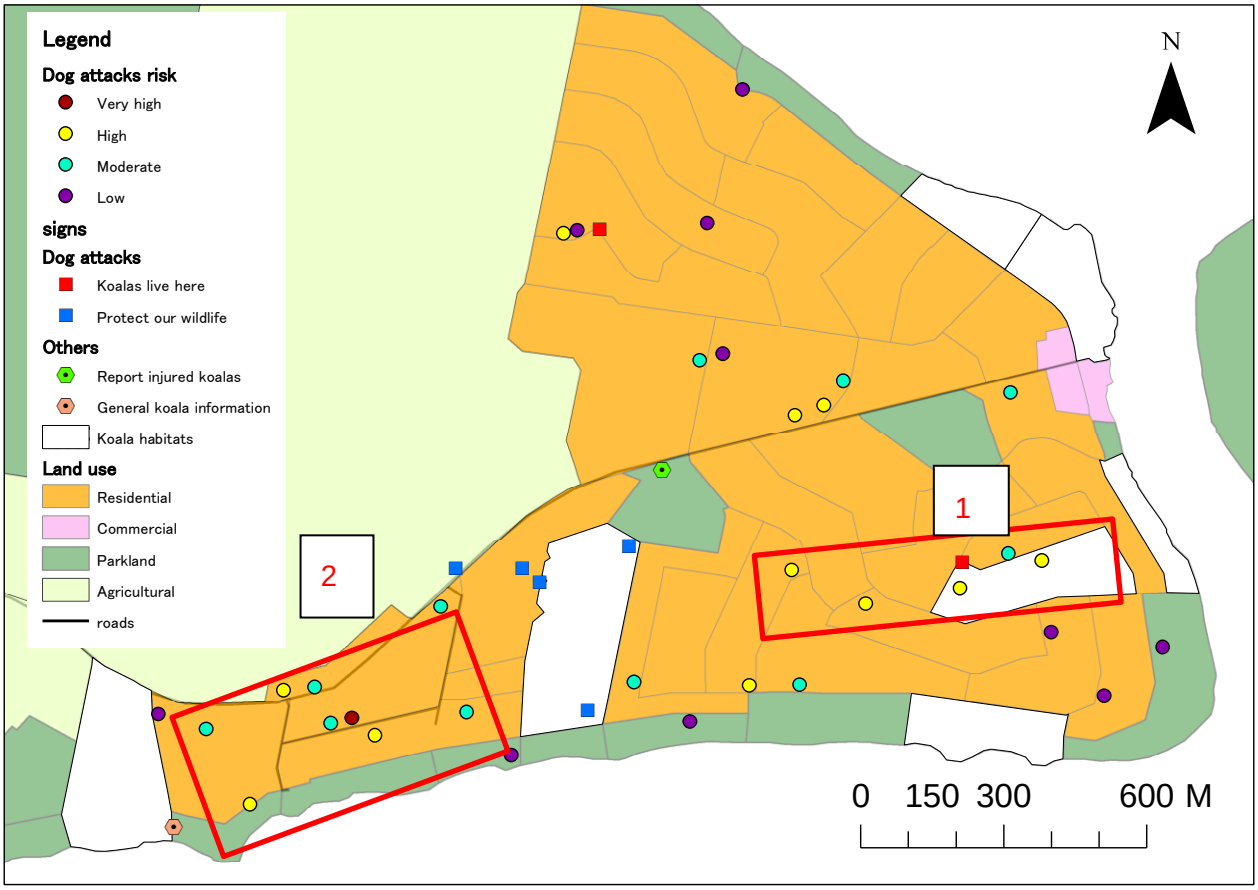

Figure 13 The dog attacks risk by dog conditions

Source: Field survey

There is no distinct distribution pattern in dog attacks risk by its level except for those of low risk. Overall, high dog attacks risk locate around the koala habitat area1 (number 1 in the Figure) and the residential area 2(number 2 in the Figure13) where surrounded by koala habitats and forests areas. On the other hand, the low dog attacks risk is mostly in outward of the land, especially in the southeast coast. Additionally, they occur more in parklands than in residential areas where higher risk heavily take place.

The low risk at parklands may reflect residents' high awareness to koalas because residents in those areas often see koalas. In fact, in the interviews with four people living in parklands at the south east coast, all of them said they see koalas every week although its frequency dramatically decreased. One of them even used to volunteer at a koala conservation organization nearby. Although those interviews cannot be generalized due to its small sample size, frequency to see koalas hints at high awareness to them.

5. Local Policy on dog management and their awareness

5.1 Assessment of dog management in Port Stephens

A summary of a response from the Port Stephens Council concerning their dog management in CKPoM is in the table in the next page (Table 14)

Table 13 Situations of each action against dog attacks on koalas in CKPoM in Port Stephens

Table 14 Each action plan on dog management in CKPoM in Port Stephens

Action Plan		Priority[1]	Effort[2]	Effect[3]	PSC[4] Comments
Prosecute owner of any dog that attacks a koala, where evidence available	Law Enforcement	H	A	A Because the responsible owners receive hefty fines and have control orders put on the dogs	-The biggest challenge is to get evidence. -Often, we are not able to find the dog that attacked. -Some members of the public are reluctant to act as a witnesses
Split Rangers' shifts to enable greater availability for dog control	Dog Registrations		C One off operations for afterhours only	N	Not feasible because animal control is only one of many other aspects of the Rangers role that mostly require dayshift.
Undertake an investigation into the number of unregistered dogs in areas where dogs are impacting on koalas			A	N Unable to measure attacks prevented	PSC has just completed a registration program that was staged over the whole Council area. The program took 12 months to complete.
Provide more appropriate dog exercise areas as part of its current policy review	Educations, Promotions, Information	H	N	N	PSC undertook a review of dog exercise areas over the last 12 months with extensive consultations with Tilligerry community
Ensure all public reserves are appropriately signposted		M	A	A	Signs enable people to be aware of the requirements for their dog and enable PSC to better enforce unlawful activity
Media campaign including pamphlet drops in identified problem areas		M	A	A There have not been any reported dog attacks on Koalas since the campaigns	Regarding the last reported dog attack on a koala in Tilligerry, PSC conducted a media campaign and an enforcement campaign
Programs encouraging dog registration to raise funds for education of responsible dog ownership			D	N	PSC rangers conduct additional night patrols during koala breeding season, but mostly the patrols are limited to daylight hours

[1]High (H), Moderate (M), Low (L), Blank (Not mentioned)

[2]A (Work very hard), B (Work to some extent), C (Not work hard that much), D (Not work on), N(Unsure)

[3]A (Very effective), B (Somewhat effective), C (Not really effective), D (Not effective), N (Unsure)

[4] Port Stephens Council

Overview of dog management in Port Stephens

The action plans in the table regarding dog management mainly range from three topics from law enforcement, dog management, and educations. In particular, actions on education are more often than other two topics, suggesting that it is especially important. As for the Port Stephen's effort on each action, they work through the best at the most of actions regardless of the priority except for nightshift of rangers who patrol households to control unregistered dogs. Moreover, each action's evaluation of the effect appears to be difficult because the Port Stephens council has yet to assess 4 actions out of 7. This implies at the need of evaluation method. Furthermore, the difficulties in getting the evidence of which dog attacks koalas is considered to arise because most of dog attacks occur at night(Phillips et al, 2011). As for peoples' reluctance to be a witness of dog attacks, two different reasons are possible depending on whether the

witness is dog owners or not. In the case of dog owners, not only their sense of guilt (Lunny et al, 1999) but also low placement such as fines and control seem to discourage them to report the attacks on koalas by their dogs. In the case of non-dog owners' witness, possibility to cause trouble between them and responsible dog owners may keep them from reporting. Additionally, in educations, settings of signs at reserve areas are promoted and their effect are considered positive, according a staff in Port Stephens However, there is no policy regarding what information should be included in the signs nor signs settings outside reserve area.

Challenges in Port Stephens' dog management

Firstly, establishment of evaluation method as to dog management is needed to see if their management properly addresses dog attacks on koalas. The lack of clear method to measure the effect of each action on dog attacks on koalas prevails in policy and literature as well. For example, Queensland government provides detailed prevention of dog attacks on koalas such as design of fencing or pools, dog confinement, or signs (QLD DEHP, 2012), but no research has not demonstrated its effect. Similarly, although keeping dog inside house would be effective considering most dog attacks on koalas

happen at night (QLD DEC, 2008), no research has proved its efficacy with quantitative data.

In the case of port Stephens, measurement of dog attacks prevented through increased dog registration is difficult. This is considered to be because dog management takes comprehensive approach with implementations of several actions at the same time at different level, period, and sections from law legislations, local educations, to rangers' shift. Although it would be hard to account for dog attacks number only from dog registrations, some effective evaluation methods that synthesize the effect of each action as well as the effect as a whole is required for better action to be implemented.

5.2 The locals' awareness to dog attacks on koalas in Lemon Tree Passage

Overview of respondents

Answers concerning their awareness to koalas from 35 respondents were collected through a questionnaire in Lemon Tree Passage. The sex of respondents was balanced with male and female accounting for almost half each and chi-square test shows no difference between the proportion of this survey and that of in the lemon tree passage. (Figure14).

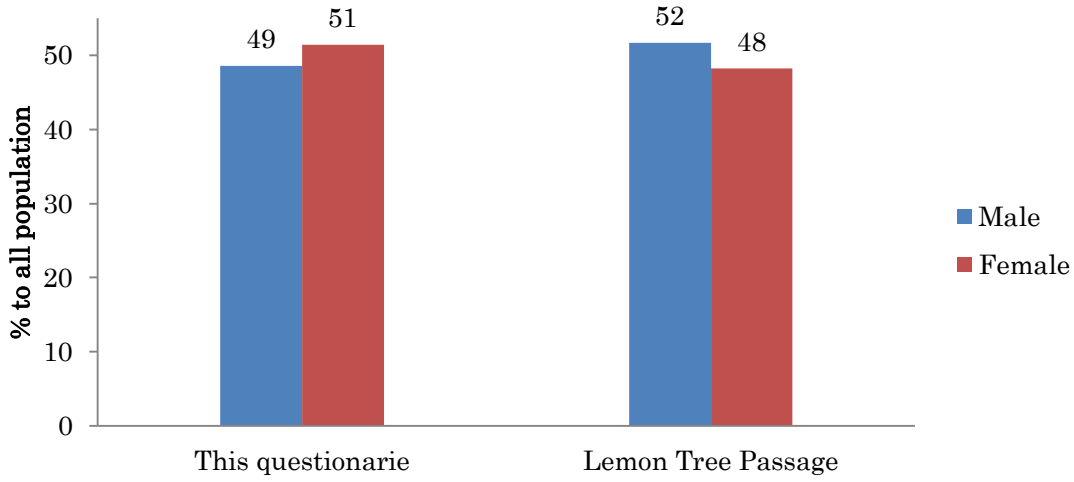

Figure 14 Sex of respondents

Their age range was broad from under 18 to over 85 and similarly, no difference was found between the sample of this questionnaire and the demography in the lemon tree passage.

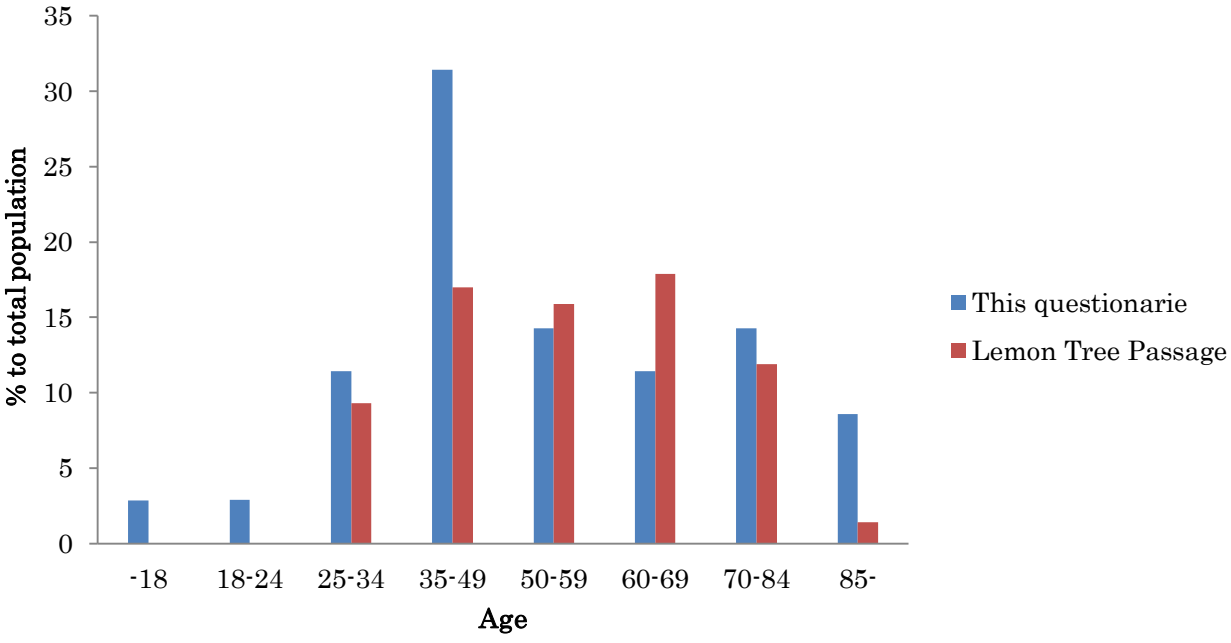

Figure 15 Age ranges of the respondents

The gap between awareness and actions

46% of respondents see koalas more than once every six months (Figure 16), and this is considered to be high. This is because even in the Logan city, which is one of the most richest koala population areas in Australia, those who see koalas in that frequency accounted 25% in the community survey(Logan City Council, 2012).

Moreover, 88 % of respondents at least have some concern to koalas (Figure17). This high Figure suggests their concern to koalas is high. However, more than half of respondents (54%) do not take any actions for koalas in terms of backyard design where most koalas die from being attacked from dogs (Figure 18).

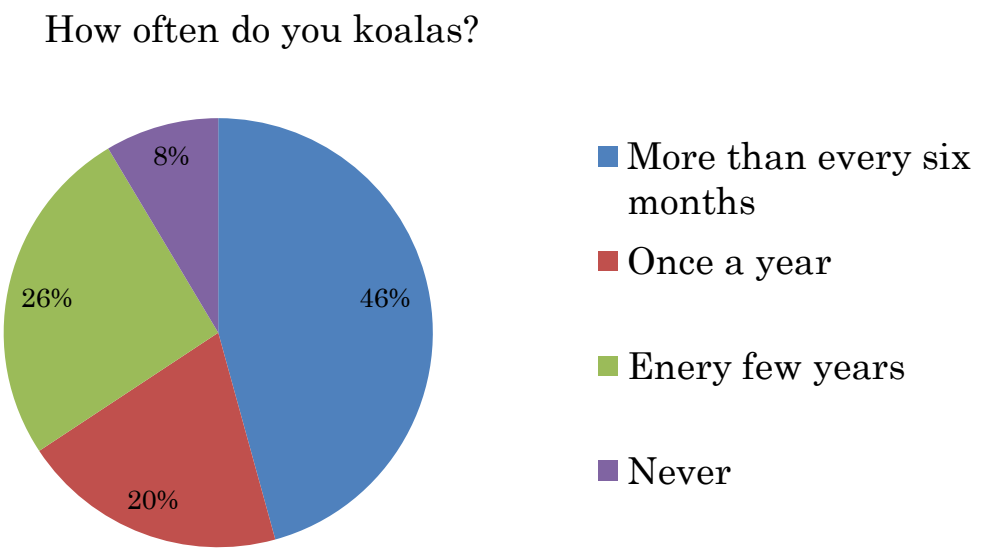

Figure 16 Response of the question about sightings of koalas (N=35)

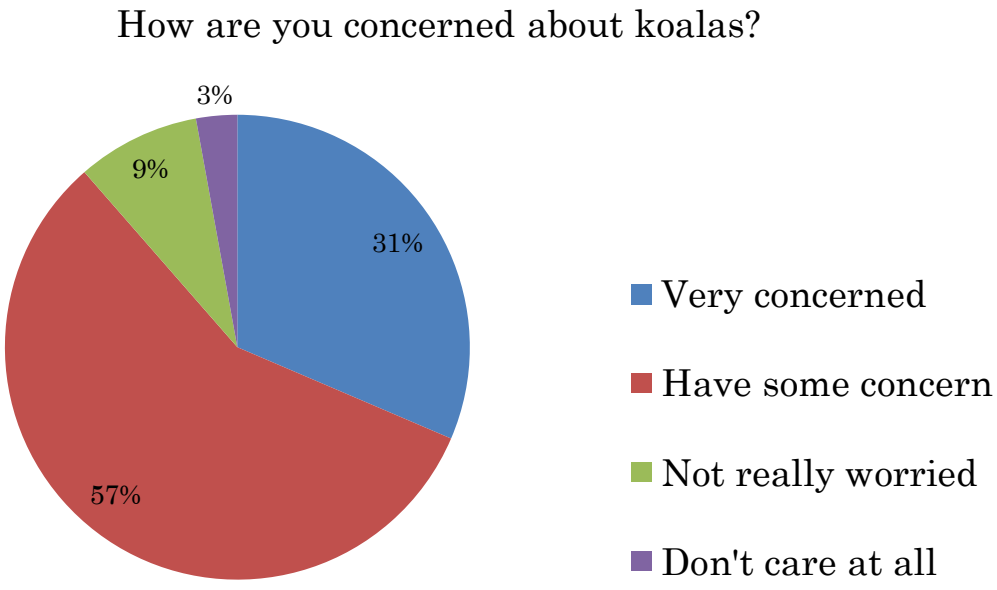

Figure 17 Response of the question about their concern (N=35)

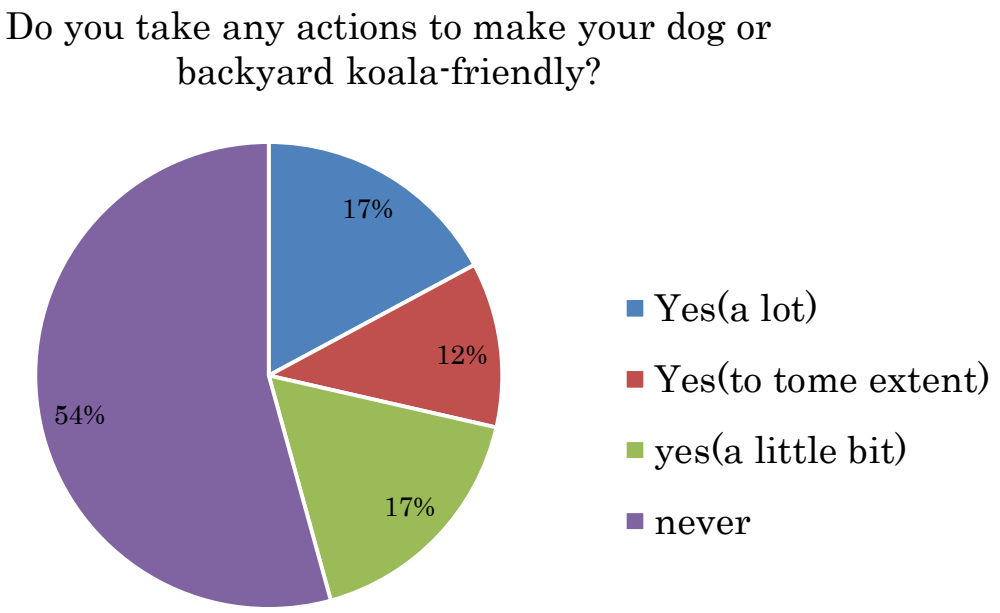

Figure 18 Responses of the question about koala friendly actions (N=35)

Moreover, among those answered taking some actions for koalas, only 5 people out of 31 respondents(16%) keep their dog inside at night, which is considered to be single the most effective to prevent dog attacks on koalas(QLD DEHP, 2006b). Other koala friendly actions that are recommended by DEP and Australian Koala Foundation, such as koala tree planting, escape rope, or dog training were also not common. As a whole, those who practice actions that are specifically effective for koala accounted for only 30% of those taking some actions for koalas. What is

more, only 2 respondents take multiple measures in koala specific actions and none practice all of koala specific actions.

Table 15 Actions practiced by the respondents

Category	Actions		Total
General responsible dog ownership	Dogs confined in yard	9 29%	19 61.3%
	Have appropriate fencing in yard	7 22.6%	
	Walk dogs on lead	3 9.7%	
Koala specific actions	Dog inside at night	5 16.1%	9 30%
	Plant koala-friendly trees in yard	2 6.45%	
	Rope for koala escape	1 3.23%	
	Train dogs not to chase koalas	1 3.23%	
Others		3 9.7%	3 9.7%
Total		31	

Source; Field survey

Unrecognition of threats of dog attacks and need of education

Only 26% of respondents recognized that dog attacks are within the top causes of declining number of koalas (Figure 19). Only 8% of respondents answered dog attacks to be the threats to koalas, followed by land clearing (42%), bushfire (21%), and roads (19%) (Figure20). This Figure implies decline of awareness in 1992 where 95% of households regarded dogs as a cause of decreasing number of koalas (Lunney et al, 2001).

3 respondents also commented that they didn't know that dog attacks are issue for koalas. This suggests that it is hard to encourage people to take action for preventing dog attacks on koalas because they think other reasons are more serious.

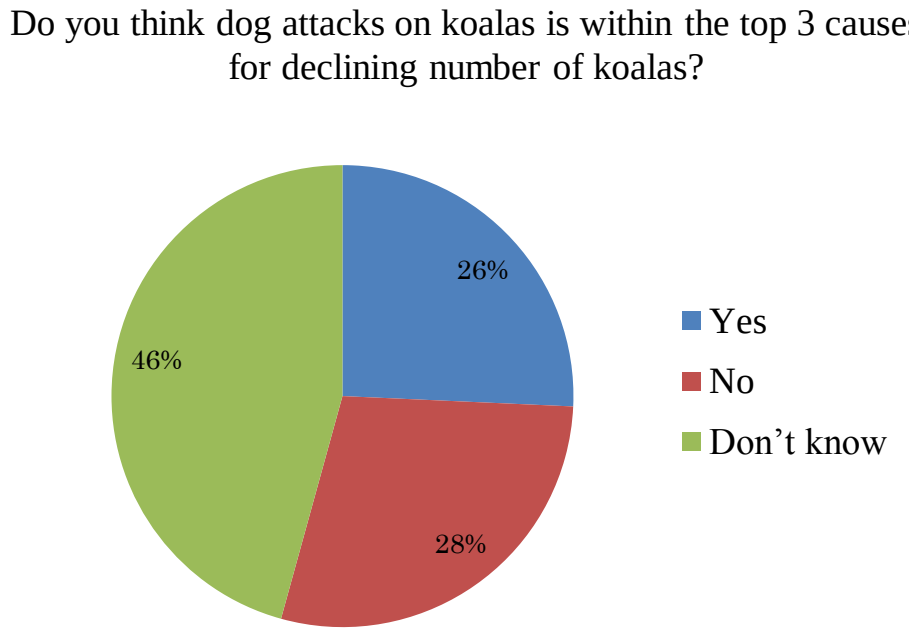

Figure 19 Responses of the question about threats of dogs on koalas (N=35)

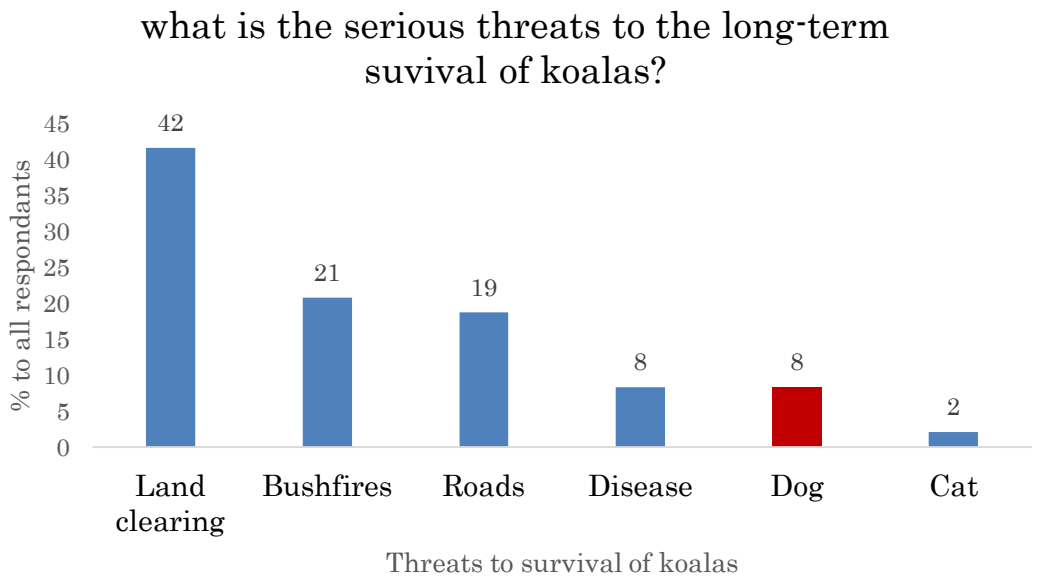

Figure 20 Responses of the question about serious threads on the survival of koalas (N=44) (Multiple answers allowed)

However, dog control ranked the first (35%) as effective measures to prevent dog attacks on koalas. The next follows educations to dog owners with 20% of respondents. Considering that legislations on dog control have been already implemented for sixteen years under the Companion Animals Act 1998, those results suggest that dog attacks should be prevented by education to dog owners along with legislations.

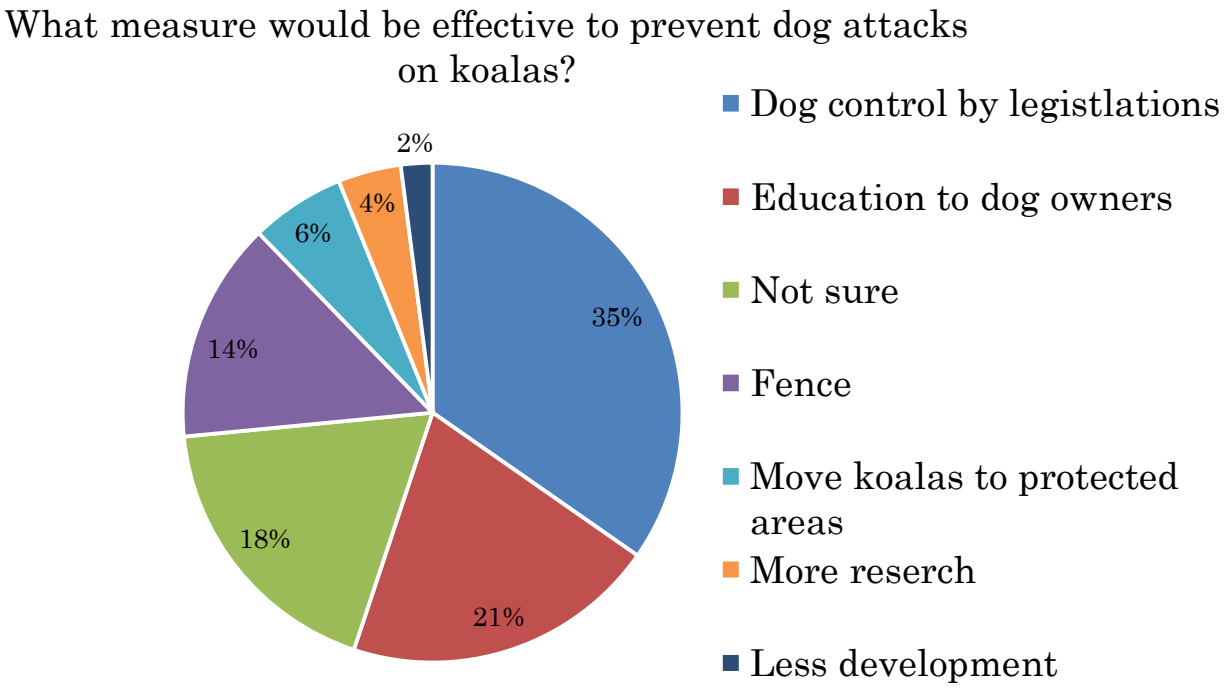

Figure 21 Responses of the question about effective measures to prevent dog attacks on koalas (N=35)

However, educations to dog attacks in Lemon Tree Passage appear to be insufficient. For example, 63% of respondents think education on koalas by Port Stephens council is not effective with 43% answering inadequate and with 21% very poor(Figure 22).

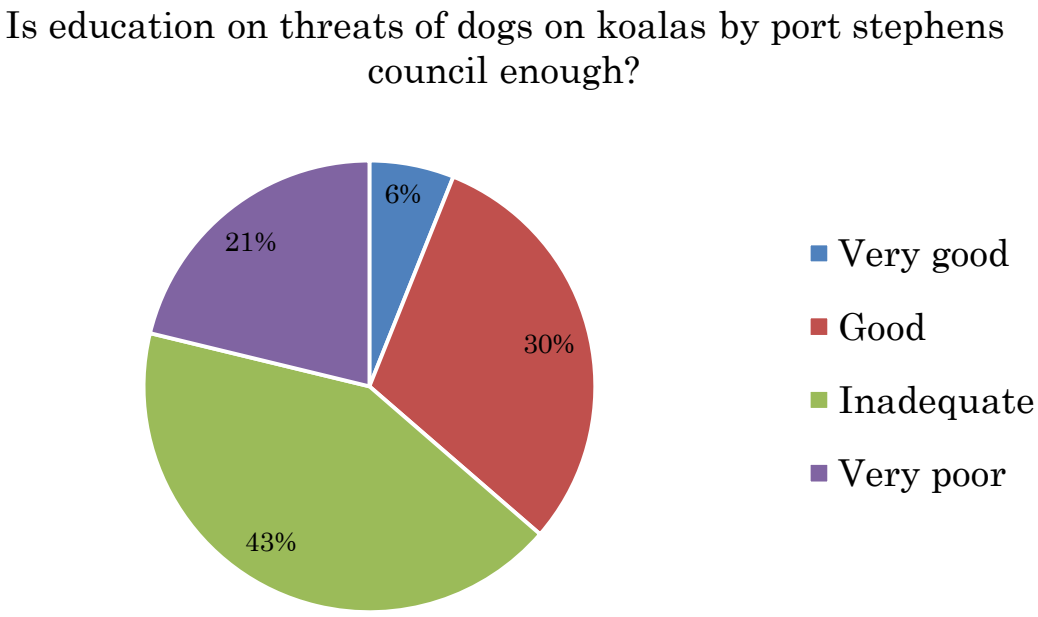

Figure 22 Responses of the question about education on dog attacks on koalas by Port Stephens Council (N=35)

According to a man, who has been living in the lemon tree passage throughout his life for 50 years, he has never seen campaign or promotions on dog attacks on koalas in the lemon tree passage. This may reflect lack of education on dog attacks on koalas in Lemon tree passage. Moreover, another woman in her 40's who has been living for more than 20 years, also commented that signs are the only things she has ever come across as educational tool in the lemon tree passage. The absence of educations itself rather than their ineffective contents, were suggested.

Those shows positive attitude on education in Port Stephens named signs and reporting platform as reasons. However, both signs and reporting system is not sorely for dog attacks but for other reasons such as road kills and disease as well. Therefore, their positive attitude is considered not to properly reflect the effectiveness of education particularly on dog attacks on koalas.

Moreover, 60% of respondents do not know whether what the council is doing concerning conservation of koalas in general (Figure 23). This may derived both from their indifference to koalas or insufficient commitment of the council

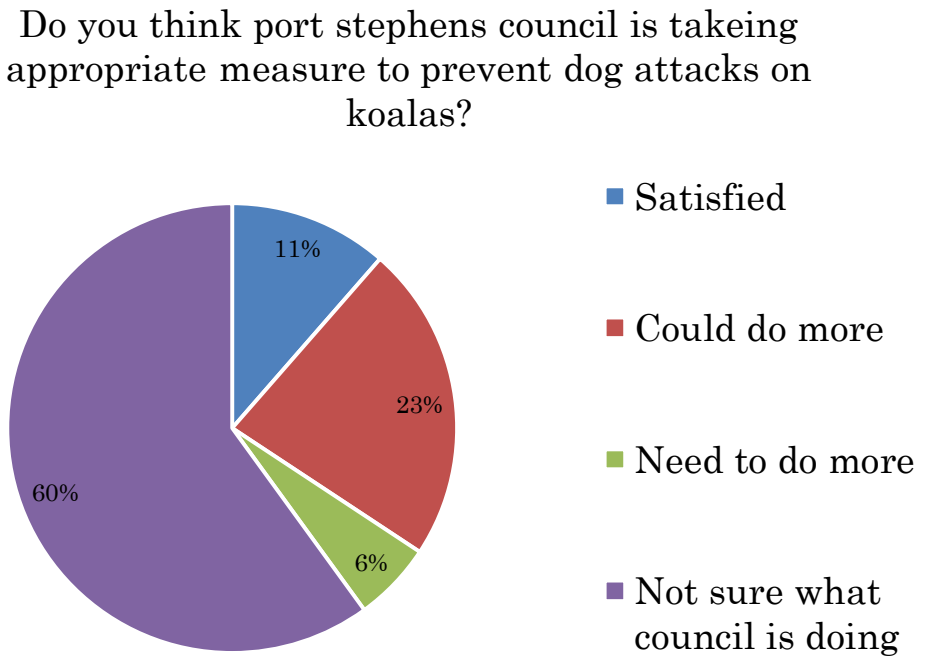

Figure 23 Response of the question about education on dog attacks on koalas by Port Stephens Council (N=35)

Information source on dog attacks on koalas

57% of respondents have seen information on dog attacks on koalas, and their main source is TV, followed by newspapers with 28% of respondents.. In contrast, friends, family and acquaintance, websites including non-governmental and governmental sites, and posters were not common for a source of information on dog attacks on koalas.

This implies that information tools that are a part of daily life are more effective for informing people about dog attacks on koalas than those that need active involvements.

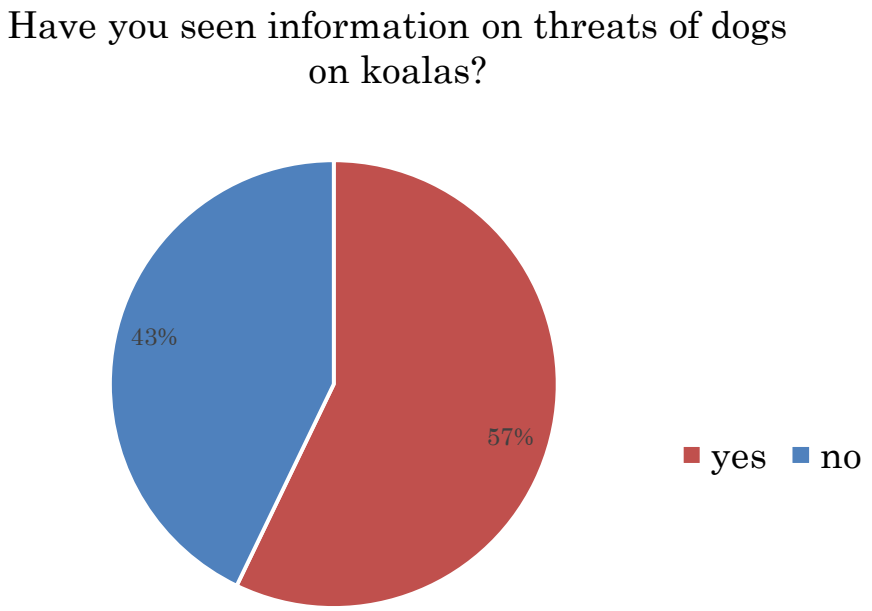

Figure 24 Response of the question about the information on threats of dogs on koalas.

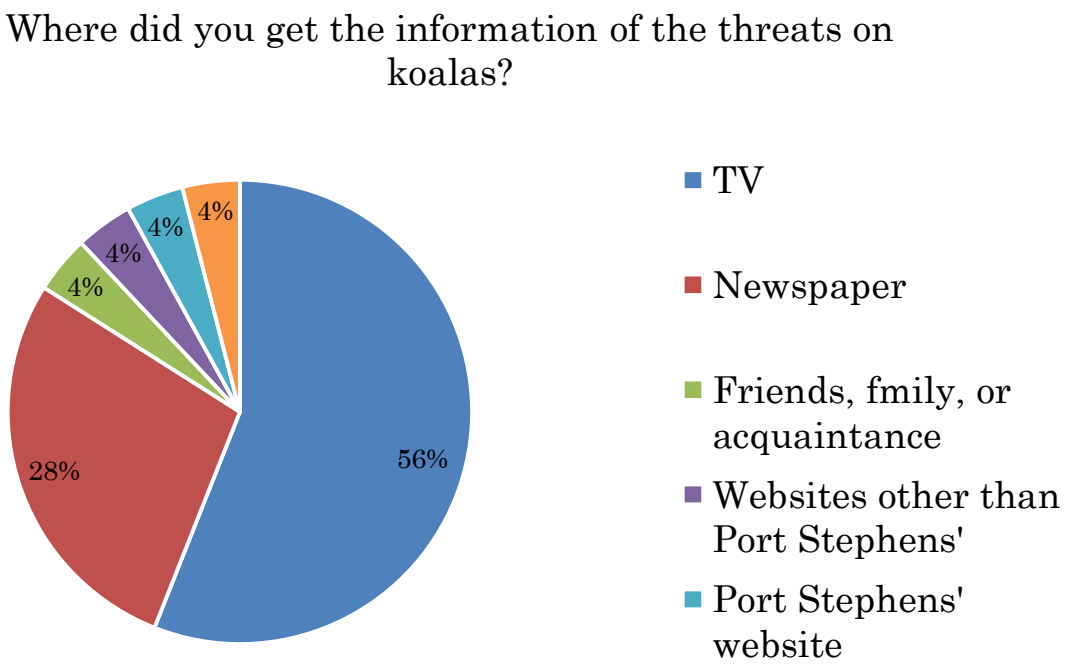

Figure 25 Response of the question about source of information on threats to koalas

Free-roaming dogs

Free-roaming dogs are greave threats to koalas (e.g. P. Smith & J. Smith, 1989; ANZECC, 1998; McAlpine et al 2006) and 60 % of respondents see them regularly from always, often to sometimes around their neighborhood. In detail, those who see koalas sometimes consist of the most (37%) and this moderate occurrence of free-roaming dogs may make their control become difficult. This is because both local people and government may overlook the issue if it is not significantly serious. Moreover, free roaming

dogs can be both stray and pet dogs whose owners irresponsibly let their dog widely move around. Thus, different measure should be taken for each from patrolling for wild dogs and fines for irresponsible dog owners. Although Port Stephens's council assessed those fines for irresponsible dogs take effect in an email inquiry (Table 13), this may not be the case in Lemon Tree Passage. This is because Port Stephens local area covers the area of 979 km^2 with 64807 populations and those of Lemon Tree Passage (1.8km^2areas with 2534populations) only consist of 0.2% and 3.9% of them, respectively. Dog management assessment at smaller divisions is advised as regional difference may take place, which determines whether the plan properly resolve dog attacks on koalas or not.

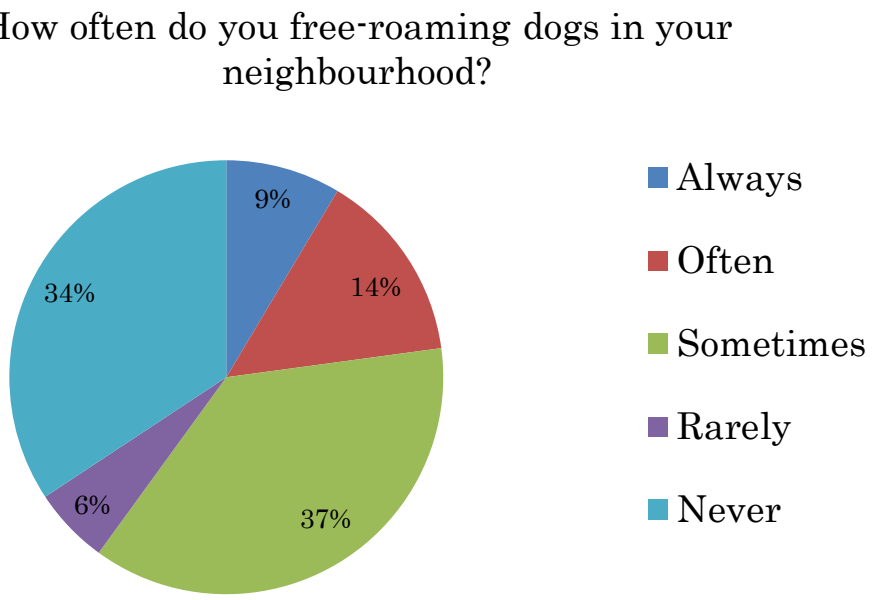

Figure 26 Response of the question about sightings of free-roaming dogs

Dog attacks reporting

Dog attacks seem not to be a great concern in the lemon tree passage anymore compared to the past. This infrequent tendency of dog attacks on koalas may therefore lead to the low action rate of dog owners to keep their dog inside at night and other actions, no signs asking them to do so, and unrecognition of dogs as a threat to koalas. Some possible causes of fewer occurrences of dog attacks than in the past would be decline of koala population, absence of reporters who used to be actively check and report dog attacks, or decreased awareness. However, whether the dog attacks reports have something to do with awareness has not revealed.

Suggestions by the locals toward koala conservation

As for prevention of dog attacks on koalas, some respondents made suggestions on it (Table 16)

Table 16 Suggestions by the locals on koala conservation

Dog attacks	Educations	Development
Thorough dog registrations and their monitoring	-Different types of approach(e.g. internet, postings, TV) to reach out to wider audience -More signs	-Not to destroy corridor -Stop cutting on trees -Reuse trees rather than through them away.

Source: Field surveys

Rigid dog registration is also priority in the port Stephens but its monitoring at night when most dog attacks take place has found to be a challenge because of staffs' dayshift. Educations other than signs, which seem to be the only education related to koalas in the lemon tree passage, should be implemented and especially long-term program is required to effect the change to their action, not to awareness only. In order bridge gap between awareness and actions, a long-term community engagement such as school curriculum, weekly newsletter, press releases or workshops rather

than temporary event such as campaign or event would be effective to cultivate interest and care for koalas. For example, a video for school on how to protect koalas and koala reference collection of a local library has been provided by a local university and NGO in Campbell town City Council (Callaghan et al, 2003). As for the development, securing their habitat is a key and it is also proved to be the most crucial for survival of koala (Sherwin et al, 2000; Cogger et al. 2003) and this is also inducing dog attacks on koalas (Hume, 1990; Rhodes et al, 2006).

6. Discussions

Principle findings of this research

First principal finding of this research is that distributions of dog attacks on koalas mostly occurred in residential areas as both in SA and QLD analyzed. Secondly, when it comes to urban and rural segmentations, their distributions differs in SA and QLD with attacks densely occurring in urban areas in SA and with them widely dispersed and taking place in rural areas in QLD. Thirdly, other than around major cities, their distributions also made slight concentrations at sub-urban city areas, suggesting their distributions have something to do with populations. Fourthly, preventing dog attacks at night is difficult because of staff's dayshift in the port Stephens, suggesting the need of its prevention by dog owners by themselves. Fifthly, the awareness to dog attacks on koalas of the locals in the lemon tree passage seemed to be low, reflected by low action rate of its preventive measures taken by dog owners, limited message on signs to avoid dog attacks on koalas, and unrecognition of dogs to be threats to koalas.

Comparison with previous research

Understandings of where dog attacks on koalas occur both at regional scale and local scale will facilitate koala conservation (Malo et al, 2004). Detection of their distribution patterns in the regional scale will help improved design of large reserve areas, road alignments (Forman & Alexander, 1998), and new development coupled with koalas' habitats(Lunney et al, 2000), populations(Clark et al, 2000), connectivity(McRae et al, 2012), and corridor(Irish & Kavanagh, 2011), which will mitigate koala death. Similarly, where dog attacks on koalas happen with respect to local scale will enable where exactly signs, patrolling, and dog exercise areas to be put on.

As to landscapes where dog attacks on koalas take place, agricultural lands close to urban area as well as those that are far away from urban areas and all surrounded by the same agricultural landscape can be added to those previously mentioned from such as semi-urban area, rural holdings close to urban cities, parkland (ANZECC 1998; NRMMC 2009). Moreover, ANZECC (1999) also reveals that fenced yards both in urban and rural and residential areas are often related to dog attacks. In this research at the lemon tree passage, all households of dog owners whose dogs are outside indeed confined their dogs within their fenced yards. Therefore, fenced

yard suggests dog owners who keep their dogs outside and that seems to be why dog attacks on koalas are linked with it.

Furthermore, providing educations not only to dog owners but also to community as a whole should be made, as Queensland government attempts to it in their koala conservation plan (QLD EPA, 2006b). Even non dog owners can inform the threats of dogs on koalas to dog owners by word of mouth, or even community member with high awareness to koala may undertake patrolling whether they have dog owners or not. Community initiatives, for instance, patrolling neighbors to check if dog owners keep their dog inside at night, would be helpful as day shift and other task of government staff make patrol of improper dogs at night when a majority of dog attacks occur infrequent. In this implementation, targeting elderly and more educated people may be practical as this is the case in participation of koala conservation project in SA(Hollow et al, 2015) and also this is typical in other community initiated activities on wildlife(Brossard et al, 2005; Purcell et al, 2012).

Moreover, higher action rate for preventing dog attacks on koalas by dog owners who live close or within to koala reserve areas than those living in residential areas separated from koala habitats corresponds to the study by Shumway et al(2014). Their study reveals that respondents' attitude toward

koala conservation heavily correlated with their home's proximity to intact koala habitats and area of residence was the most influential to the attitude.

Moreover, although knowledge of species increases demands for conservation of sustaining of the species (Tisdell & Wilson,2006) that for threats does not necessarily lead to significant conservation (McKenzie-Mohr et al, 2012). Therefore, education for koalas themselves along with threats of dogs should be provided. Besides, the action of keeping dog inside at night is a clear solution, it has high chance of behavioral change (Collier & Smith, 2009; Schultz, 2011), if promoted properly.

What is more, low recognition of dogs to be threats to koalas showed different result from where it has more attention by respondents because of its frequent occurrence in media (Harris & Goldingay, 2003). Indeed most of respondents who have seen information on dog attacks on koalas named newspaper and TV as its source, they did not think they are as serious as they actually are. More appropriate way of communication would be required to make the most of their frequency in media. Additionally, strong support for stricter dog control for koala conservation demonstrated the same tendency with other research (Harris & Goldingay, 2003; FitzGibbon & Jones, 2006).

Additionally, proper signs should be made if installed although sign postings are used mostly for mitigations of road kills (Lunney et al, 1996; Marin & Handasyde, 1999; Smith, 1990; Forman et al, 2003). As for their contents, picture of koalas is in particular said to be effective (Port Stephens Council, 2002; QLD DEHP, 2012), but no distinctive methods for putting effective message on signs has provided in prevention of dog attacks on koalas. Thus, what message and pictures are especially take effect on promoting actions should be established. Concerning its locations, public places with exposure to wider audience, (QLD EPA, 2012), koala reserve areas (Port Stephens Council, 2002; Callaghan et al, 2003; QLD DEHP, 2006b) and koala habitats (Callaghan et al, 2003) are recommended for its settings, but it seems to be insufficient considering the number of people who regularly visit those areas. Therefore, sign settings at other areas where people often come across such as residential roads, city hall, or library may be needed.

Finally, although large number of dog owners in a local council keep their dog inside at night, it is still insufficient to maintain koala population throughout Australia (Lunney et al,2001). Thus, all levels if governments ranging from national, states, and local scale should cooperate each other (McAlpine et al, 2005).

Strength and weakness of this research

The strength of this research lies on the use of geographical distributions combined with statistical, quantitative, or quality data. Those two data make up for insufficient information for each other, enabling deeper understandings of situations. For instance, two signs specific to koalas located on where dogs were present nearby, but it seemed not promote them to take actions for preventing dog attacks on koalas based on observation and questionnaire. Thus, government may better change the message on them or allocate their budgets not to signs but to workshops on dog attack on koalas.

On the other hand, the weakness is in data collection of dog attacks where bias by the source would be high and small sample size. Another weakness is the lack of positioning of study area based on the result of distributions of dog attacks on koalas. The characteristic of their distributions by land use and by urban and rural segmentation do not connected closely with the field survey. The characteristics and comparison of distribution patterns of dog attacks on koalas were investigated in SA and QLD, but study area was in New South Wales where no were no their distribution patter was revealed.

7. Conclusion

Distributions of dog attacks on koalas revealed two different patterns with urban type in SA where their density is significantly high at relatively small areas and with rural type in QLD where they are scattered from south east coast to inland but still hold cluster around a large city.

On top of that, the awareness to dog attacks on koalas of locals in Lemon Tree Passage where used to have high density of dog attacks appears to become lower in the past. The ineffective signs may also fail to educate dog owners, causing large number of dogs outside at night when most dog attacks occur. Moreover, because government staff who are in charge of patrolling of dogs have day shift, they cannot regularly advise dog owners to keep their dog inside at night. Thus, the need for education to dog owners both in terms of responsible dog ownerships and limitation of government has been unfolded. The implications of this research is the predication of dog attacks on koalas based on the feature of the area from urban, semi-urban, to rural as well as on dog owners' actions and dog conditions including their size and where they are. The estimated dog attacks risk can be implemented into dog management and koala conservation plan. As future study, comparison of dog attacks risk in urban

and rural area which shows different distribution patters in this study is considered

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